VIDEO-BASED ELECTRONIC SURVEILLANCE FOR HAND HYGIENE AUDITING: AN EXPLORATORY AND EVALUATIVE STUDY

Katherine Jane McKay

RN IPN MAdvPrac(Hons1) GCertAdvNurs(CritCare) GCertAdvNurs(ClinNursEd) CertWT&A CICP-A

A thesis submitted in fulfilment of the requirements

for the degree of Doctor of Philosophy

Susan Wakil School of Nursing and Midwifery

Faculty of Medicine and Health

University of Sydney

Referencing system: Numbered

ABSTRACT

BACKGROUND

Hand hygiene is recognised as the most important thing that a healthcare worker (HCW) can do to prevent the patients in their care from acquiring a healthcare associated infection (HAI). Practice is both guided and audited according to the WHO 5 Moments for Hand Hygiene framework, with the direct human observation method being considered the gold standard method for compliance data collection. While this approach has its benefits, questions regarding its efficacy, accuracy and cost-efficiency have recently come to light. Various electronic systems have been suggested as a potential solution, and although they are not without their advantages, most rely on proxy measures rather than the 5 Moments as a compliance metric meaning that the ability to measure actual adherence to optimal infection prevention practice is limited. Video-based systems offer possibilities for recording and auditing hand hygiene behaviours in such a way that actual compliance can be ascertained according to the WHO 5 Moments framework. However, this has yet to be explored by way of systematic, sustained research.

This thesis explored the utility of video-based surveillance as a method of hand hygiene compliance auditing. It argues that video-based surveillance approaches may have utility in terms of feasibility and time efficiency for auditing hand hygiene according to the WHO 5 Moments. The thesis reports 3 interconnected studies that in concert examine the utility of video-based surveillance as a method of hand hygiene compliance. Study 1 explored the technical and methodological specifications that might be required for the use of video-based monitoring systems (VMS) for hand hygiene compliance auditing. Study 2 examined the feasibility and timeefficiency of the video-based approaches for hand hygiene compliance auditing by way of a trial. Study 3 unearthed the acceptability of video-based surveillance methods for hand hygiene auditing to HCWs and patients.

METHODS

A pragmatic, mixed-methods study was undertaken across three interconnected studies that aligned with each of the research questions described above. Study 1 comprised a comprehensive, in depth, critical narrative review of the literature as well as interviews with key informants, including content experts, front line auditors, infection prevention and control clinicians and department managers as well as methodological and technical experts. Interview transcripts underwent content and thematic analysis and this information, combined with the literature review and the advice of

technical and methodological experts, lead to the development of a video-based approach to hand hygiene auditing.

Study 2 was a pragmatic observational proof-of-concept trial in simulation of VMS technology for hand hygiene auditing with a series of simulated clinical care activities in the New South Wales Biocontainment Centre. The participants were volunteer HCWs who participated relative to their professional designation, as well as students who undertook the role of patients. Scenarios were recorded using 3 different video modalities. Recorded footage was audited according to the WHO 5 Moments framework by a qualified and validated Gold Standard Hand Hygiene Auditor who also conducted an assessment of the accuracy, efficiency and cost-effectiveness of the system and the process of auditing from recorded footage. Post-simulation group interview transcripts underwent content and thematic analysis.

Study 3 comprised a qualitative investigation of the acceptability of VMS to HCWs and patients via 2 group interviews with participants in the Study 2 proof-of concept trial, as well as though both online surveys and additional individual interviews. In total, 24 interviews were conducted with key informants on a voluntary basis to further explore key themes. Interviews were transcribed, and again thematic and content analysis was used to identify themes and meanings from the data. Descriptive statistical analysis of survey responses was combined with data which emerged from the interviews to more fully illuminate HCW and patient attitudes to the use of VMS for hand hygiene auditing.

RESULTS

This doctoral study reveals that the utility of VMS for auditing hand hygiene compliance according to the WHO 5 Moments for hand hygiene. It offers technical and methodological specifications required for effective and efficient data collection in order to allow auditing according to the WHO 5 Moments were also the features and operational parameters which promoted acceptability by HCWs and patients. Both the proof-of-concept trial and input from participants and respondents identified a suite of specifications needed for a VMS for hand hygiene auditing, as well as areas that will need further clarification and/or legislative mandate. In particular, participants identified features such as the use of HCW proximity activation for camera recording, rear or overhead camera placement, automatic facial pixilation and the absence of audio recording as essential. In addition, the use of a recording in progress indicator, a simple user interface, the ability for patients to be able to deactivate the system and the ability to easily review the footage were seen as beneficial features to include. Methodological considerations included an appropriate legislative mandate to cover recording within the patient zone, clarification of the requirements for

consent as well as the legal status of the footage in terms of retention, deletion and discoverability. Participants also highlighted the need for assurances regarding confidentiality of and access to recorded footage, as well as clarification and codification of the feedback process for HCWs.

VMS auditing according to the WHO 5 Moments is not only possible but it obtains much more data that is possible with human auditors via direct observation. The literature suggested that HCW and patient attitudes in terms of acceptability of the approach could be a potential barrier to the use of VMS within the patient zone. However, this thesis has demonstrated that although HCWs often cite the invasion of privacy as a barrier to the use of video, patients themselves do not appear to object provided certain technical and methodological features and protections are in place. HCWs were generally accepting of VMS, seeing the advantages of the approach in relation to efficiency in terms of the time taken to audit, however also expressing fears in terms of the receipt of negative feedback or punitive consequences. It was also clear that a variety of legislative issues relating to privacy, consent, legal status of footage, retention and deletion and open disclosure would need to be taken into consideration.

CONCLUSIONS

This research has demonstrated the utility of video-based surveillance for hand hygiene auditing. Such systems can not only capture hand hygiene practice suitable for auditing against the WHO 5 Moments criteria, but have the potential to do so in an efficient, cost-effective and accurate manner. Relevant local contextual legal and other considerations such as privacy, consent and status of the system are necessarily relevant therein. Moreover, this research demonstrated a level of acceptability of vide-based surveillance to HCWs and patients. This study involved a proof-of-concept simulated trial to establish the system parameters, feasibility and time efficiency. Future research should undertake in vivo experimentation of the technology and methodology.

STATEMENT OF AUTHENTICITY

This thesis is submitted to the University of Sydney in fulfilment of the requirements for the degree of Doctor of Philosophy. The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part for a degree at this or any other institution.

Katherine Jane McKay

30 November 2022

DEDICATION

For my Father

John Morris Burt

(1940 – 2016)

Who would have been so chuffed

and

For those infection prevention and
control nurses who audit hand
hygiene compliance with honesty
and integrity despite it all.

ACKNOWLEDGEMENTS AND FUNDING FOR THE STUDY

This study was supported by a University of Sydney PhD candidate stipend, and a 2020 Seed Funding Grant from the Sydney Institute for Infectious Disease at the University of Sydney.

I owe so much to so many that it is hard to know where to start.

To the participants, particularly those who took part in the Study 2 Trial – thank you, thank you for sharing with me your thoughts, feelings, and fears. For being open, honest, and enthusiastic, even when you didn't agree with me, perhaps even more so then!

To Shizar, Christina, Keren thank you for holding my hand and guiding me through the maze of NSW Health when I came up to Sydney and for all the other times you were there at the end of the phone or computer to help in so many ways.

To Dr Cecilia Li and Dr Trish Ferguson – Associate Supervisors, thank you for your support, advice, suggestions, mentoring, encouragement, patience, generosity …. the list of superlatives is boundless and so is my gratitude to you.

For the delightful Catherine Viengkham for your masterful assistance with proof reading and making the thesis look right – you are an absolute tech wizard! Thank you!

To my Mother Jean, who has never understood what I have been doing or why but has been there for me in a million practical and helpful ways nonetheless, we show love and support in so many different ways and I am so grateful for yours.

To my dearest colleague and mentor Helen Marquand, your positivity, kindness and above all your belief that I would be able to do this has been so wonderful for so long. Thank you!

And saving the best for last, the person without whom I would never have dared to even dream that this journey was a possibility, Professor Ramon Shaban. I thank you from the depth of my heart and my soul for your support, encouragement and guidance. For pulling me out of the proverbial rabbit holes when I got stuck down them, for the metaphorical slaps to the face and the injunctions to keep calm and carry on when I was having hysterics and perhaps most importantly the unwavering belief that I **could** do this and do it well when I didn't believe any such thing myself. For being there whenever I have needed you despite a global pandemic. You rock! Thank you, a thousand times, over.

Katherine Jane McKay

ABBREVIATIONS AND ACRONYMS

TERM	DEFINITION
ABHR	Alcohol Based Hand rub: An alcohol-containing preparation (liquid, gel or foam) designed for application to the hands to inactivate microorganisms and/or temporarily suppress their growth. Such preparations may contain one or more types of alcohol, other active ingredients with excipients, and humectants. The antimicrobial activity of alcohols is attributed to their ability to denature and coagulate proteins. This causes microbes to lose their protective coatings and become non-functional.
ACSQHC	The Australian Commission on Safety and Quality in Health Care is a corporate Commonwealth entity which works in partnership with patients, consumers, clinicians, managers, policy makers and healthcare organizations to achieve a sustainable, safe and high-quality health system. It develops and delivers policies and programs and advises the Australian Government on health, aged care and sport as well as working with a wide range of stakeholders to ensure better health for all Australians.
AM shift	Also referred to as a 'morning' shift - usually 0700hrs to 1530hrs or thereabouts.
ANTT	Refers to Aseptic non – touch technique. ANTT is an international set of principles aimed to: Standardize practice, support HCWs to practice safely and effectively, increase patient safety by reducing the risk of introducing infection into a susceptible body site during procedures such as intravenous therapy, wound care and urinary catheterisation. ANTT involves identifying the ‘key parts’ and ‘key sites’ of a procedure and not touching them either directly or indirectly ensuring an aseptic procedure.
Direct Observation	Direct observation of hand hygiene is the standard practice recommended by the World Health Organization to monitor its compliance and is defined as a method of collecting data in which an auditor simply views the subjects of the data collection without asking specific questions or manipulating any variables.
EMS	Electronic Monitoring System: an umbrella term which may be interchangeable in the literature with terms such as ‘electronic’, ‘computerized’, ‘automated’ or ‘video-based’ surveillance methods for monitoring HCW compliance with hand hygiene.
FLHCW	Frontline Healthcare Worker – a HCW who engages in clinical care involving interactions with patients or clients and who is not a hand hygiene auditor.
GINse/GIDr	Group Interview Participant – Nurse or Doctor
GSA	Gold Standard Auditor (Hand hygiene). An auditor trained under the auspices of the NHHI who is validated and certified able to train other (general) hand hygiene auditors as part of the Australia NHHI.

HAI/HCAI	Hospital Acquired Infection/ Healthcare Associated Infection: describes an infection that is acquired as a direct or indirect result of healthcare. Healthcare-associated infections are one of the most common complications affecting patients in hospital. An infection is generally deemed to be healthcare associated if it is not present on admission to a healthcare facility but occurs more than 48 hours after admission or within 2 to 90 days of discharge (depending on the location of the infection and the nature of the treatment received).
Hand Hygiene	A general term referring to any action of hand cleansing. Includes; Applying an alcohol-based hand rub to the surface of hand OR Washing hands with the use of a water and soap or a soap solution, either non-antimicrobial or antimicrobial.
Hawthorne Effect	Generally accepted as being a form of responsiveness where individuals modify an aspect of their behaviour in response to their awareness of being observed.
IPAC/Infection Control	Infection Prevention and Control Service, also known as Infection Control. In the Australian context this is a healthcare-based service largely staffed by senior nurses with responsibilities for infection prevention activities, mandated data collection and surveillance programs as well as staff health including immunisation.
NBC	The New South Wales Biocontainment Centre (NBC) is a new service to enhance state-wide preparedness to effectively respond to future pandemics and manage patients (adult and paediatric) with high-consequence infectious diseases. It is located in the Central Acute Services Building at Westmead Hospital and was the site of the Study 2 Trial in simulation.
NHHI	National hand Hygiene Initiative: The Australian Commission on Quality and Safety in Healthcare established the National Hand Hygiene Initiative in 2008 as part of a suite of initiatives to prevent and reduce healthcare-associated infections in Australian healthcare settings. The National Safety and Quality Health Services (NSQHS) Standards require health service organisations to have a hand hygiene program consistent with the NHHI and jurisdictional requirements.
NPZ-NFC	Non-Patient Zone - Non-fixed camera. A simple, continuously recording camera placed at the observation window of the NBC - Q classroom. The footage captured approximates the view that a human auditor would experience from this vantage point.
Patient Zone	Refers to a space temporarily dedicated to the care of a single patient. The concept developed as part of the World Health Organization's Five Moments of hand hygiene aims to distinguish surfaces primarily contaminated by flora of a single patient i.e., inside the patient zone (for example the patient's room or bed bay within a shared space) from those outside the patient zone (shared areas or the healthcare zone) containing foreign and potentially harmful microorganisms.
Peer/Local Auditor	A General auditor, trained by a GSA who both works clinically in a department and conducts hand hygiene auditing there.

PPE	Personal Protective Equipment protects the healthcare worker from exposure to blood and body fluids/substances. PPE should be readily available and accessible in all health services and may include gloves, impermeable gowns, plastic aprons, masks, face shields and eye protection.
SAB	Staphylococcus aureus bacteraemia - a blood stream infection with the organism staphylococcus aureus (also known as "golden staph"). May be hospital or community associated. All SABs are reportable in Australia and the incidence rate is considered an indicator of the quality and safety of healthcare.
Standard Precautions	Standard precautions are the work practices required to achieve a basic level of infection prevention and control. They are the minimum infection prevention and control practices that must be used at all times for all patients in all situations. Standard precautions should be used in the handling of: blood (including dried blood); all other body substances, secretions and excretions (excluding sweat), regardless of whether they contain visible blood; non-intact skin; and mucous membranes.
TBP	Transmission-Based Precautions are used in addition to standard precautions, where the suspected or confirmed presence of infectious agents represents an increased risk of transmission.
Telehealth	The distribution of and access to health-related services and information via electronic information and telecommunication technologies (e.g. telephone, video-conference platforms). It allows long-distance patient and clinician contact, care, advice, reminders, education, intervention, monitoring, and remote admissions.
VMS	Video-based Monitoring System: a camera-based auditing system that involves the recording of HCW hand hygiene behaviour and the subsequent evaluation of the footage by an auditor to establish compliance according to a predetermined compliance criterion.
WHO	The World Health Organization is a specialized agency of the United Nations responsible for international public health. The WHO Constitution states its main objective as "the attainment by all peoples of the highest possible level of health".
WHO 5 Moments for Hand Hygiene	Framework for optimal hand hygiene practice - categorises the indication for hand hygiene into 5 classification of HCW:Patient interaction; 1. Before patient contact 2. Before a procedure 3. After a procedure or body fluid exposure 4. After patient contact 5. After contact with the patient environment
WPZ-FC	Within Patient Zone - Fixed Cameras: pre-existing cameras within the NBC. 8 cameras per biocontainment suite which are in fixed positions for maximal room coverage and which record continuously when activated. Footage is routinely retained for 21 days but may be exported for review using the Milestone XProtect SmartClient_viewer software.

WPZ-NFC	Within Patient Zone - Non-fixed Cameras. Refers to the 4 cameras installed for the Study 2 Trial. Cameras could record continuously or activate via a blue tooth beacon resulting in a 'tracked" footage sequence. A facial pixilation privacy filter was also able to be applied. Footage was reviewed using VLC media player, this is a free and open-source cross-platform multimedia player and framework that plays most multimedia files, and various streaming protocols.

TABLE OF CONTENTS

Abstract iii

Background iii

Methods iii

Results iv

Conclusions v

Statement of Authenticity vi

Dedication vii

Acknowledgements AND Funding for the Study viii

Abbreviations and Acronyms ix

List of Figures xvii

List of Tables xxi

List of Appendices xxiii

Publications Arising from the Study and Thesis and Attestation of Authorship xxv

The Thesis 1

Chapter 1: Introduction 2

Contemporary Problems for Quality and Safety in Healthcare: Healthcare-Associated Infections 2

The Role of Microorganisms, Hands and Hand Hygiene in Preventing and Controlling HAIS 4

Defining Hand Hygiene 6

Contemporary Types and Measures of Hand Hygiene: The WHO 'My 5 Moments' 7

Measuring and Monitoring Hand Hygiene Compliance 9

Direct Observation – The 'Gold Standard' for Compliance Monitoring 10

Advantages of Direct Observation 11

Disadvantages of Direct Observation 14

Current Compliance and Direct Observation 25

The Research Problem 26

Aims of the Study 26

Outline of the Thesis 27

Chapter 2: Literature Review 29

Introduction 29

Electronic Monitoring System Solutions for Problems Associated with Direct Observation 29

Electronic Monitoring Systems and the Research Problem 30

Electronic Monitoring Systems – Definitions and System Parameters 30

Hand Hygiene Product Usage or Event Counting Systems *31*
Tag-Based, Zone and Locational Systems *33*
PURPOSE AND INTENT OF ELECTRONIC MONITORING SYSTEMS 35
ADVANTAGES OF ELECTRONIC MONITORING SYSTEMS 36
Gathering Big Data *36*
Reducing Human Resources for Data Collection *38*
Reducing Bias in Data Collection *39*
Electronic Monitoring Systems and the Hawthorne Effect *39*
Providing Feedback and Changing Behaviour *42*
DISADVANTAGES OF ELECTRONIC MONITORING SYSTEMS 45
Use of Proxy Measures of Compliance *45*
Expense of Electronic Monitoring Systems *50*
Accuracy of Data *53*
Alarm Fatigue *56*
Staff Concerns About Surveillance – 'Big Brother is Watching' *59*
THE APPLICABILITY OF ELECTRONIC MONITORING SYSTEMS TO SOLVING THE RESEARCH PROBLEM 64
VIDEO-BASED MONITORING SYSTEMS – A POTENTIALLY USEFUL CATEGORY 64
Technical and Functional Aspects of Video-Based Systems *69*
Advantages of Video Monitoring Systems *71*
Video Monitoring Systems and the Hawthorne Effect *75*
Disadvantages of Video Monitoring Systems *79*
CRITICAL CONSIDERATIONS OF THE LITERATURE FOR THE STUDY 85
Chapter 3: Methods 87
Study Design *87*
STUDY 1 – TECHNICAL AND METHODOLOGICAL SPECIFICATIONS 89
Study Design *89*
Data Collection *89*
Ethical Considerations *92*
Data Analysis *93*
STUDY 2 – FEASIBILITY AND TIME EFFICIENCY 96
Aim of the Study *96*
Study Design *96*
Data Collection *96*
Ethical Considerations *102*
Data Analysis *103*
STUDY 3 – ACCEPTABILITY FOR HEALTHCARE WORKERS AND PATIENTS 104
Study Design *104*
Data Collection *105*

Group Interviews *105*
Surveys and In-Depth Individual Interviews *106*
Online REDCap Survey *107*
Interviews *107*
Interview Structure *108*
Ethical Considerations *111*
Data Analysis *112*
Chapter 4: Results 113
INTRODUCTION 113
STUDY 1 – TECHNICAL AND METHODOLOGICAL SPECIFICATIONS 113
Introduction *113*
Purpose *113*
Participant Demographics *113*
Participants' View Regarding Direct Observation *119*
Strengths of Direct Observation *119*
Limitations of Direct Observation *123*
First Impressions - VMS *128*
Technical and Methodological Issues Associated with Video-Based Monitoring Systems *129*
Technical and Methodological Specifications *148*
Summary *149*
STUDY 2 – FEASIBLITY AND TIME EFFICIENCY 150
Participant Demographics *150*
Within Patient Zone – Fixed Cameras (WPZ-FC) *151*
Non-Patient Zone – Non-Fixed Cameras (NPZ-NFC) *154*
Within Patient Zone – Non-Fixed Camera (WPZ-NFC) *156*
Other Uses for the Footage *161*
STUDY 3 – ACCEPTABILITY 163
Participant Demographics *163*
Introduction *167*
Theme 1: Protecting Patient Privacy *168*
Theme 2: Making Healthcare Workers Feel Safe *184*
Comparison between Responses to Direct Observation and VMS *190*
Theme 3: Open Communication *192*
Theme 4: The 'How' and 'When' of Feedback *199*
Theme 5: Better Data, Better Feedback, Better Care *210*
Summary *221*
Chapter 5: Discussion 223

Introduction 223
Methodological and Technical SpecificationS 223
Technical Features *224*
Methodological Specifications *227*
Accuracy, Efficacy and Efficiency 236
Acceptability OF VMS to Healthcare Workers and Patients 240
Summary 244
Chapter 6: Conclusions 246
Background and Purpose of the study 246
Summary of the Key Findings 246
Critique and Limitations of the Research Method and the Study 248
Implications of the Study 250
For the Practice of Hand Hygiene Auditing *250*
For Regulation, Legislation, Guidelines, Policy and Procedure *253*
For Communication, Education and Training *254*
For Future Research *256*
Conclusion 256
References 258
Appendices 275

LIST OF FIGURES

Figure 1. The WHO 'My 5 Moments' for Hand Hygiene (source: https://www.who.int/campaigns/world-hand-hygiene-day). 7
Figure 2. National Hand Hygiene Compliance - 2017-2019 (NHHI). 25
Figure 3. Pre-existing camera in the NBC. 98
Figure 4. Floorplan of the NBC showing the location of the pre-existing fixed cameras. 99
Figure 5. Sample output from the fixed cameras in the NBC. 99
Figure 6. Temporarily installed novel VMS cameras placed in the NBC for the proof-of-concept trial. 100
Figure 7. Floorplan of NBC showing placement of temporary Novel VMS cameras. 101
Figure 8. Floorplan of NBC with indication of placement of NPZ-NFC which mimics human auditor viewpoint. 102
Figure 9. Example footage showing hand hygiene auditor performing direct observational hand hygiene auditing. 109
Figure 10. Example of footage from pre-existing camera array (WPZ-FC) showing multiple camera view and single camera view. 110
Figure 11. Sample output from the temporarily installed cameras forming part of the novel VMS, demonstrating the rear (above bed) camera positioning. 110
Figure 12. Sample footage demonstrating privacy filter resulting in facial identification and the application of a blurring filter. 111
Figure 13. Count of Phase 1 participants' statements about the purpose of direct observational hand hygiene auditing. CE = content experts, MOD = managers of data, COD = collectors of data, ROD = recipients of data. 115
Figure 14. Participants' stated beliefs about the accuracy of the hand hygiene rate submitted to the NHHI according to participant category. 116
Figure 15. Auditing style according to participant. 117
Figure 16. Participants who raised or did not raise "patient privacy" as major issue in the use of a VMS for hand hygiene compliance according to participant category. 137
Figure 17. Within Patient Zone – fixed cameras (WPZ-FC) – overall Moments according to scenario. 152
Figure 18. Sample of footage recorded and subsequently audited using the pre-existing cameras in the NBC – the multiple camera array meant that the HCW hand hygiene journey could be followed, and compliance could be measured according to the WHO 5 Moments. 153

Figure 19. Hand hygiene compliance according to trial day and Moment as audited from footage recorded with the WPZ-FC in the NBC – demonstrating the ability to measure compliance according to the WHO 5 Moments. 154
Figure 20. Overall hand hygiene compliance according to trial day and HCW as audited from footage recorded with the WPZ-FC in the NBC – compliance is according to the WHO 5 Moments. 154
Figure 21. Views from Non-Patient Zone – Non-Fixed Camera (NPZ-NFC) showing an auditable hand hygiene Moment and an obstructed view. 155
Figure 22. Hand hygiene compliance as audited from footage recorded with the NPZ-NFC in the NBC – demonstrating the ability to measure compliance according to the WHO 5 Moments as a proxy for the view of a human auditor conducting direct observation. 155
Figure 23. Sample footage exported from Within Patient Zone – Non-Fixed Cameras showing the quad-camera view. 157
Figure 24. Auditing time according to scenario and method in comparison to overall duration of scenarios – trial day one. 159
Figure 25. Quad screen view illustrating lack of synchronisation. Top left image and bottom right showing the activity in the same room but with an approximately 10-minute discrepancy in timing. 159
Figure 26. Sample of Day 2 footage illustrating the rebooting of the camera and subsequent loss of footage. 160
Figure 27. Comparison of compliance according to method and Moment – overall Day 1 and Day 2 of trial. 161
Figure 28. Comparison of compliance according to method and HCW – Day 1 and Day 2 of trial. 161
Figure 29. Example of additional uses to which recorded footage could be put as a demonstration of the utility of the approach – participant correctly donning PPE in the anteroom as audited from recorded footage. 162
Figure 30. Example of additional uses to which recorded footage could be put as a demonstration of the utility of the approach – a PPE breach where the participant is noted to apply ABHR to gloves. 162
Figure 31. Example of additional uses to which recorded footage could be put as a demonstration of the utility of the approach – potential to audit compliance with ANTT using a VMS. 163
Figure 32. Participant demographics – proportional breakdown by gender and data collection method. 164
Figure 33. Breakdown of HCW participants according to professional designation. 164
Figure 34. Breakdown of HCW Survey & Interview Participants according to residential location. 166

Figure 35. Breakdown of Surveyed HCWs' workplaces. 167
Figure 36. Survey participants' responses to the statement 'the use of a VMS would be an invasion of patient privacy'. 169
Figure 37. HCW survey respondents' responses to the statement 'Patients would be accepting of the use of VMS for hand hygiene purposes'. 169
Figure 38. Survey respondents' responses to the importance of the feature 'Cameras only record when the HCW is present'. 173
Figure 39. Survey respondents' responses to the importance of the feature 'Facial blurring or pixilation'. 174
Figure 40. Survey respondents' responses to the importance of the feature 'Cameras placed directly overhead'. 175
Figure 41. Survey respondents' responses to the importance of the feature 'Cameras placed behind the head of the bed'. 176
Figure 42. Sample footage demonstrating side, front and rear (+/- facial blurring) camera placement. 176
Figure 43. Survey respondents' responses to the importance of the feature 'Not recording audio'. 177
Figure 44. Survey respondents' responses to the importance of the feature 'Warning light/sign when recording is taking place'. 178
Figure 45. Survey respondents' responses to the importance of the feature 'Audible tone when auditing starts'. 178
Figure 46. Survey respondents' responses to the importance of the feature 'There is the option to turn the camera off at any time during patient care'. 181
Figure 47. Survey respondents' responses to the importance of the feature 'Patients can turn the camera off'. 181
Figure 48. Survey respondents' responses to the importance of the feature 'HCWs can turn the cameras off'. 182
Figure 49. Survey respondents' responses to the statements 'I would be unhappy having my practice recorded' (HCWs) or 'Staff would be unhappy having their practice recorded' (Patients). 184
Figure 50. HCW survey respondents' responses to the statement 'The use of the VMS would cause me to feel like 'Big Brother' is watching'. 185
Figure 51. HCW survey respondents' responses to the statement 'I would worry that any hand hygiene mistakes I make in the footage could be used in evidence against me'. 189
Figure 52. HCW survey respondents' responses to the statement 'Being able to review the footage of my hand hygiene practice would be useful for my training and learning'. 205

Figure 53. HCW survey respondents' responses to the statement 'If I realize hand hygiene auditing is taking place, I become more aware of my hand hygiene'. 211
Figure 54. HCW survey respondents' responses to the statement 'My hand hygiene practice remains the same, regardless of the presence of the auditor'. 212
Figure 55. Survey respondents' responses to the statement 'I think that I would soon forget about the cameras' 215
Figure 56. HCW survey respondents' responses to the statement 'Auditing via the VMS footage would be faster and less resource intensive than direct observation' 217

LIST OF TABLES

Table 1. Moments collected and submitted to the NHHI from 2018 to 2021. Calculations are based on figures suggested by Azim & McLaws (2014): 2.2 minutes per Moment and a AU$50 per hour auditor wage. 19
Table 2. Study outline with phases, research questions and data collection methodologies. 89
Table 3. Overview of proof-of-concept trial in simulation. Includes details of scenarios and the recording modalities used each day. 97
Table 4. Footage recorded according to day, scenario and recording modality. 102
Table 5. Sample size and characteristics of Phase 3 interview participants. 108
Table 6. Phase 1 interview participant demographics. 114
Table 7. Phase 1 interview participants, breakdown of workplace type according to participant category. 114
Table 8. Phase 1 participants – breakdown of auditing experience and average Moments collected per month according to participant category. 115
Table 9. Negative language used by participants in relation to direct observational auditing. 127
Table 10. Themes relating to the use of VMS for hand hygiene compliance. 130
Table 11. Negative emotions, words and phrases associated with the use of video-based auditing for hand hygiene compliance. 140
Table 12. Summary outline of the technical and methodological specifications of video-based approach to hand hygiene auditing as derived from Phase 1 interviews and discussions with technical and methodological experts. 149
Table 13. Comparison of scenario duration and time taken to audit from recorded footage - including number of Moments identified and compliance rate. 151
Table 14. Breakdown of hand hygiene compliance according to scenario and Moment as audited from footage recorded with the pre-existing cameras in the NBC demonstrating the capacity to audit according to the WHO 5 Moments. 153
Table 15. Overall compliance according to Moment as measured using footage recorded with the Non-Patient Zone – Non-Fixed Camera. 156
Table 16. Comparison of the time taken to audit using WPZ-FC and WPZ-NFC versus the overall duration of the scenarios. 158
Table 17. Comparison of Moment yield and time taken to audit across all recording approaches 160
Table 18. Participant demographics – count breakdown by gender and data collection method. 164
Table 19. Participant demographics – age of survey and interview participants across categories. 165

Table 20. Comparison of years practicing as a HCW across participant categories. 165
Table 21. Comparison of the years of experience as a hand hygiene auditor between survey and interview participants. 165
Table 22. Themes and subthemes emerging from the Study 3 data. 167
Table 23. Auditor and FLHCWs' responses to direct observation auditing statements. 190
Table 24. Patient survey respondents' responses to the statement 'Do you believe that patient consent is required to conduct hand hygiene auditing using novel VMS?'. 192
Table 25. Patient survey respondents' responses to the statements concerning consent to use VMS for hand hygiene auditing. 193
Table 26. Survey Respondents – frequency of feedback provision by auditors and receipt of feedback by auditors and FLHCWs in relation to direct observational hand hygiene auditing. 200
Table 27. HCW survey respondents' responses to statements regarding their feelings about and responses to feedback related to direct observational hand hygiene auditing. 201
Table 28. Auditor survey respondents reported negative responses to the provision of feedback related to hand hygiene compliance. 203
Table 29. Technical and methodological specifications for a video-based monitoring system to record hand hygiene compliance for auditing according to the WHO 5 Moments 225

LIST OF APPENDICES

Appendix A: McKay, K.J., Shaban, R.Z., Ferguson, P. (2020). Hand hygiene compliance monitoring: Do video-based technologies offer opportunities for the future? Infection Disease and Health. 25(2), pp. 92-100. doi.org/10.1016/j.idh.2059.12.002.

Appendix B: McKay, K.J., Ferguson, P.E., Shaban, R.Z. (2021). Methodological and technical considerations for video-based auditing of hand hygiene compliance: an exploratory study. American Journal of Infection Control. 49(11), pp. 1384-91. Doi.org/10.1016.ajic.2021.04.081.

Appendix C: McKay, K.J., Li, C., Shaban, R.Z., (2022). Using Video-based surveillance for monitoring hand hygiene compliance according to the World Health Organisation (WHO) 5 moments framework: A pragmatic trial. Infection Control and Hospital Epidemiology. First View, pp. 1-7. doi.org/10.1017/ice.2021.509.

Appendix D: McKay, K.J., Li, C., Shaban, R.Z., Ferguson, P.E., Sotomayor-Castillo, C., Wyer, M. (2022). Healthcare workers' experiences of video-based monitoring of hand hygiene behaviours. American journal of Infection control. In press, corrected proof available online 22 March 2022. doi.org/10.1016/j.ajic.2022.03.010.

Appendix E: Phase 1: Interview Question Guide.

Appendix F: Phase 1: Human Research Ethics Committee, The University of Sydney – Phase 1: letter of Approval: Project 2019/387: May 2019.

Appendix G: Phase 1: Eastern Health Office of research and Ethics: Letter of Approval to recruit at Eastern Health.

Appendix H: Phase 1: Participant Information Statement.

Appendix I: Phase 1: Participant Consent Form.

Appendix J: Technical Specifications of the Novel VMS trialled in Phase 2.

Appendix K: Phase 2: Simulation Scenario Outlines for proof-of-concept trial in simulation.

Appendix L: Phase 2: Group Interviews Question Guide

Appendix M: Human Research Ethics Committee, Western Sydney Local Health District – Phase 2: letter of Approval: Project 2020/PID03547.

Appendix N: Phase 2: Participant information and consent form.

Appendix P: Phase 3: HCW online survey data collection tool (hard copy).

Appendix Q: Phase 3: Patient online survey data collection tool (hard copy).

Appendix R: Phase 3: Interview Question Guide – Auditors and Frontline HCWs.

Appendix S: Phase 3: Interview Guide: Patients/Consumers.

Appendix T: Sample communication to HCW and Patient/Consumer associations regarding recruitment including email invitations to be mediated by the associations.

Appendix U: Phase 3: Human Research Ethics Committee, The University of Sydney – Phase 3: letter of Approval: Project 2021/040: June 2021.

Appendix V: Phase 3: Participant Information and Consent Form

Appendix W: NHHI hand hygiene data collection tool

Appendix X: Summary of themes arising from the Research

PUBLICATIONS ARISING FROM THE STUDY AND THESIS AND ATTESTATION OF AUTHORSHIP

I Katherine McKay completed this doctoral study under the supervision of principal supervisor Professor Shaban and associate supervisors Dr Patricia Ferguson and Dr Cecilia Li. The doctoral study yielded papers published in the international peer-review literature as follows:

1. McKay, K.J., Shaban, R.Z., Ferguson, P. (2020). Hand hygiene compliance monitoring: Do video-based technologies offer opportunities for the future? Infection Disease and Health. 25(2), pp. 92-100. doi:10.1016/j.idh.2059.12.002. [APPENDIX A]

   This paper was drawn from the literature review which comprises chapter 2 of the thesis. I drafted and was responsible for the manuscript under the guidance of Professor Shaban who provided critical input. Both Professor Shaban and Doctor Ferguson provided review and proof reading of the manuscript. Attribution: K McKay 80%, R.Z. Shaban 15%, P Ferguson 5%.

2. McKay, K.J., Ferguson, P.E., Shaban, R.Z. (2021). Methodological and technical considerations for video-based auditing of hand hygiene compliance: an exploratory study. American Journal of Infection Control. 49(11), pp. 1384-91. Doi.org/10.1016.ajic.2021.04.081. [APPENDIX B]

   This paper reports, in part, the findings of study 1 as described in Chapters 3 and 4 of this thesis. I drafted and was responsible for the manuscript under the guidance of Professor Shaban who provided critical input. Both Professor Shaban and Doctor Ferguson provided review and proof reading. Attribution: K McKay 80%, R Shaban 15%, P Ferguson 5%.

3. McKay, K.J., Li, C., Shaban, R.Z., (2022). Using Video-based surveillance for monitoring hand hygiene compliance according to the World Health Organisation (WHO) 5 moments framework: A pragmatic trial. Infection Control and Hospital Epidemiology. First View, pp. 1-7. doi.org/10.1017/ice.2021.509. [APPENDIX C]

   This paper describes the results of study 2 as defined in Chapters 3 and 4 of this thesis. I drafted and was responsible for the manuscript under the guidance of Professor Shaban who provided critical input. Both Professor Shaban and Doctor Li provided critical review of the manuscript. Attribution: K McKay 80%, R Shaban 1**5**%, C Li 5 %.

4. McKay, K.J., Li, C., Shaban, R.Z., Ferguson, P.E., Sotomayor-Castillo, C., Wyer, M. (2022). Healthcare workers' experiences of video-based monitoring of hand hygiene behaviours.

American journal of Infection control. In press, corrected proof available online 22 March 2022. doi.org/10.1016/j.ajic.2022.03.010. [APPENDIX D]

This paper reports the results of a segment of the study 3 data collection (interviews with study 2 participants) as described in more detail in Chapters 3 and 4 of this thesis. I drafted and was responsible for the manuscript under the guidance of Professor Shaban who provided critical input. Professor Shaban and all other listed authors provided critical review and proof reading of the manuscript. Attribution: K McKay 80%, R Shaban 5%, C Li 5%, C Sotomayor-Castillo 5%, M Wyer 5%.

5. McKay, K.J., Shaban, R.Z., (2022). Video based monitoring systems for hand hygiene compliance auditing: what do patients think? PLOS ONE: Citizen Science – Accepted, Publication Pending.

   This paper reports the results of a segment of the study 3 data collection (Surveys and interviews with consumers) as described in more detail in Chapters 3 and 4 of this thesis. I drafted and was responsible for the manuscript under the guidance of Professor Shaban who provided critical input and proof reading. Attribution: K McKay 90%, R Shaban 10%

Katherine Jane McKay

6 December 2022

THE THESIS

Video-Based Electronic Surveillance for Hand Hygiene Auditing:

An Exploratory and Evaluative Study

Katherine Jane McKay

CHAPTER 1: INTRODUCTION

This thesis is concerned with hand hygiene compliance and how it is measured. Specifically, it is concerned with the technique of capturing data about compliance and whether the use of video-based monitoring has utility in this process. It examines the current status quo and compares this with the use video-based approaches, which are also assessed feasibility and time efficiency, and, perhaps most importantly, acceptability to both HCWs and patients.

This chapter provides the background for the study, placing hand hygiene in the context of the quality and safety of patient care. The current method of assessing compliance is also examined for the strengths and weaknesses of this approach and the scene is set for the Chapter 2 literature review which examines the variety of suggested solutions to the shortfalls of the direct observation method for hand hygiene auditing.

CONTEMPORARY PROBLEMS FOR QUALITY AND SAFETY IN HEALTHCARE: HEALTHCARE-ASSOCIATED INFECTIONS

Healthcare-associated infections (HAI) are considered a major patient safety issue and a significant threat to the quality of healthcare (Boscart et al., 2008; Mitchell, Shaban, MacBeth, Wood, & Russo, 2017). A HAI which may also be referred to as a hospital-acquired infection or nosocomial infection is defined as:

> *"An infection occurring in a patient during the process of care in a hospital or other health-care facility which was not present or incubating at the time of admission… includes infections acquired in the hospital but appearing after discharge" (WHO, 2002).*

Internationally, differences exist as to specifically how a HAI is defined, however an infection is generally considered to be hospital-acquired if it manifests more than 48 hours after admission or within 2 to 90 days following discharge, depending on the site of infection, the nature of treatment, invasive procedures or surgery and the presence of implanted material such as joint prosthesis, mesh products or pacemakers (VICNISS, 2017; WHO, 2011).

The result of a HAI is a myriad of adverse outcomes for patients, their families, healthcare facilities and wider society. This includes increased patient mortality and morbidity, physical and psychological pain and suffering, increased length of hospitalisation and increased costs to individual, families, healthcare facilities and the community at large. These costs may relate to the

expense of prolonged or additional treatments, investigations, procedures or surgical interventions or to a loss of productivity and income for patients and their carers. Treatment of HAIs may consume scarce resources and may lead to promotion of antimicrobial resistance, secondary to extensive or prolonged antibiotic treatment with the further risk of spread of such organisms into the wider community upon patient discharge (Boscart et al., 2008; Martin-Madrazo et al., 2009; Momen & Fernie, 2010; Sax et al., 2007; WHO, 2016).

HAIs are the most common adverse event in healthcare and are estimated to be among the top 10 causes of death in the USA (Burke, 2003; Cheng et al., 2011; Decker, Cipriano, Tsouri, & Lavigne, 2016). However, the lack of standardised definitions and consistent national and international surveillance programs makes identification and quantification of the exact extent of the problem difficult (Mitchell et al., 2017; WHO, 2011). Overall, HAIs are estimated to affect between 7.5% and 8.7% of patients in acute care facilities (Boscart, Levchenko, & Fernie, 2010; Cheng et al., 2011; El-Saed et al., 2018). The figure may be as low as 4.5% to 7% in high-income countries (Haac et al., 2017; McGurkin & Govednik, 2015; WHO, 2016) and potentially as high as 10% to 19% in resource limited settings (El-Saed et al., 2018; Haac et al., 2017; WHO, 2016). In terms of actual numbers, this translates to between 1.7 and 2 million cases and 90,000 – 100,000 deaths per annum in the United States (Boscart, Fernie, Lee, & Jaglal, 2012; Burke, 2003; Dufour et al., 2017; Edmond et al., 2010; Stone, 2009). In Canada, the incidence is estimated be approximately 220,000 cases and 8,000 deaths p.a. (Boscart et al., 2012; Momen & Fernie, 2010), while figures for Europe suggest 3.2 million (confidence interval 1.9 – 5.2 million) HAIs each year with an associated mortality of 50,000 to 135,000 p.a. Figures for Australia are similarly imprecise due to the lack of a national surveillance program, however a review by Mitchell et al. (2017) estimated the HAI rate be as high as 165,000 cases per year.

The financial impact of HAIs not only to healthcare facilities but to society at large is significant but equally difficult to quantify. In the US various estimates have been made ranging from US$4.5 billion p.a. (Boscart et al., 2012), through US$16.6 billion (Hassan, Tuckman, Patrick, Kountz, & Kohn, 2010) US$29 billion (Cheng et al., 2011) to as high as US$96 – 147 billion (McGurkin & Govednik, 2015). In Canada the annual figure stands at approximately US$100 million (Momen & Fernie, 2010), while in Europe the estimate is €13 – 24 billion p.a. (Dufour et al., 2017). Davis (2010) suggests that the cost of HAIs to the NHS in the UK is £1 billion p.a. or between £4,000 – 10,000 per individual infection. While there is considerable range and variability in the data, is it sufficiently clear that that a significant financial burden is imposed by HAIs.

The processes by which patients acquire a HAI are complex and multifactorial. A number of features increase the risk that a patient will experience an infective complication of healthcare treatment including extremes of age (neonates and the elderly), impaired immunity, prolonged hospital admission, treatment with multiple antibiotics, emergency or unplanned admission, treatment in a tertiary hospital, admission to an intensive care unit (ICU) or chronic disease states such as diabetes, renal failure or malignancies (Manoukian et al., 2021; Stewart et al., 2021; WHO, 2002, 2011). Stewart et al. (2021) also suggest that lower socioeconomic status and frequent healthcare facility attendance or admission may also be predisposing factors for HAIs. While it is acknowledged that there is no single cause, and hence no single, simple solution to the problem of HAIs, various estimates have been made as to as to the proportion of HAIs which could be prevented via increased optimal adherence to infection prevention practices (Australian Commission on Safety and Quality in Health Care, 2017). Suetens, Hopkins, Kolman, and Hogberg (2013) suggest that 20% of HAIs are preventable. Pittet and Boyce (2001) place the figure at one-third and Boscart et al. (2012) at 50%. Dufour et al. (2017) on the other hand suggest that between 55% and 70% of HAIs would be avoided if compliance with infection prevention guidelines improved. Similarly, Umscheid et al. (2011) contend that as many as 65 - 70% of HAIs are preventable but go on to warn that 100% prevention may not be attainable with the current evidence-based prevention strategies.

D. J. Gould, Drey, and Creedon (2011) suggest that the organisms that cause most HAIs are spread via the contact route. Cohen et al. (2016) concur, citing evidence to suggest that an improvement in compliance with infection prevention activities saw a reduction in incidence of thus transmitted organisms, thereby implicating the role of HCW hands, equipment and the environment in the transmission of healthcare associated pathogens.

THE ROLE OF MICROORGANISMS, HANDS AND HAND HYGIENE IN PREVENTING AND CONTROLLING HAIS

It is well established that the hands are a significant risk factor in the transmission of microorganisms in healthcare and therefore in the development of HAIs. Organisms are present on the patient's skin, nearby fomites or in the immediate environment. During routine care these organisms transfer onto the HCWs hand where they are able to survive for sufficient time, particularly if hand hygiene is omitted or is inadequate. Organisms may then be transferred to subsequent patients, items of healthcare equipment or the environment (Boyce & Pittet, 2002; Grayson, Havers, Ryan, & Olsen, 2018a; Pittet et al., 2006; WHO, 2009). Various factors are reported to increase the risk and rate of organism transfer; including the nature of the contact (respiratory or wound care versus contact with intact skin), the duration of the contact (contamination increases in

proportion with length of contact), location of contact (wounds, devices, perineal and inguinal regions present the highest risk) and the moisture level of the donor or recipient skin (Boyce & Pittet, 2002; Pittet et al., 2006).

Although the above convincingly and logically describes the mode of organism transfer between patients and/or their environments via the hands of HCWs or healthcare equipment, it is clinical studies which have provided the most convincing and powerful evidence. Historically, the work of Hungarian Doctor, Ignaz Semmelweis, is credited as providing the "first evidence" (Pittet & Boyce, 2001, p. 9) that the use of an antiseptic agent to decontaminate the hands could reduce the rate of HAIs. In the 1840s Semmelweis described how the mortality rate from puerperal fever in the clinic where doctors came straight from the autopsy room was 5 times higher than in the clinic managed by midwives who did not perform autopsies. The mortality rates equalised when hand disinfection with chlorinated lime was mandated when attending the clinic from the autopsy room leading Semmelweis to conclude that the disease was caused by the "cadaverous particles" spread from patient to patient via HCW hands, he notes:

> *"…if those particles are destroyed chemically, so that in examinations patients are touched by fingers but not by cadaverous particles, the disease must be reduced…. To destroy cadaverous matter adhering to hands I used chlorina liquida." (Semmelweis, 2008, p. 7)*

Semmelweis is often credited as being the "the father of hand disinfection and hospital epidemiology" (Pittet & Boyce, 2001, p. 10) and is likely to have based the use of chlorinated lime on the work of Labarraque (1831) who published and promoted the use of the disinfectant for "dressing ill-conditioned sores, or as a means of purifying unhealthy places" (p.207). While Semmelweis encountered resistance to his hand washing practices, his findings, along with the work of Oliver Wendell Holmes, who in 1843 also published in support of the notion of the hands of HCWs as a vehicle for disease transmission, meant that the importance of hand hygiene as an infection prevention strategy gradually became accepted.

In the modern era a pivotal study by Mortimer, Lipsitz, Wolinsky, Gonzaga, and Rammelkamp (1962) provided powerful evidence as to the role of HCW hands in pathogen transmission and the preventative benefits of hand hygiene. The study clearly demonstrated *Staphylococcus aureus* (SA) transmission between an infected infant and 92% of subsequently handled contacts when hand hygiene was deliberately omitted. In contrast when hand hygiene was performed after contact with the infected infant only 52% of subsequent contacts developed infection, furthermore it took on average four times longer for the infants in the hand hygiene group

to test positive to SA. These results were seen as clear evidence of the role of HCW hand in the transmission of pathogens which cause HAIs.

In more recent times the sentinel and well regarded work of Pittet et al. (2000) in Geneva clearly indicated that as hand hygiene compliance and the rate of alcohol-based hand rub (ABHR) use increased the rate of HAIs decreased. The study cites improved hand hygiene compliance from 48% up to 66% with a corresponding HAI rate reduction from 16.9% to 9.9% between 1994 and 1997, hence confirming the value and role of hand hygiene in the control of MRSA and other HAIs. Numerous studies have since been undertaken, reported and reviewed in the Infection Prevention and Control body of literature and the overwhelming evidence shows "a temporal relationship between improved hand hygiene practices and reduced infection rates" (Boyce & Pittet, 2002, p. 29; WHO, 2009). It is worth noting that a number of studies including the work of Doron et al. (2011) suggest that the impact of improved hand hygiene compliance is greatest on organisms transmitted via the contact route, in this instance MRSA and VRE. Geilleit et al. (2018) has quantified the efficacy of improved hand hygiene, suggesting that for every percentage increase in hand hygiene compliance the HAI rate could decrease by 0.18 – 3.8%. In a similar vein, a study by Talbot et al. (2013) indicated that once compliance was greater than 75% there was a statistically significant reduction in device-related infections.

DEFINING HAND HYGIENE

It is now universally acknowledged that hand hygiene is the most important action that a HCW can take to prevent the patients in their care from developing a HAI (Hagel et al., 2015; Kwok, Harris, & McLaws, 2017; Ward et al., 2014). Hand hygiene is variously described as the "leading measure" (Pittet & Boyce, 2001, p. 9), "the single most important factor" (Boscart et al., 2012), "one of the most fundamental approaches" (Ellison, Barysauskas, Rundensteiner, Wang, & Barton, 2015, p. 1) and the "cornerstone" (Azim & McLaws, 2014, p. 1) of infection prevention practices in the reduction of HAIs. Cruickshank (2018) does caution however that while hand hygiene is arguably the most important strategy it is not the only strategy for the prevention of infection in healthcare. The SARS-CoV-2 pandemic (COVID-19) served to raise the importance of hand hygiene to global prominence and helped to reinforce its role as a keystone of infection prevention practice for policy makers, HCWs and the general public alike (Allegranzi, Tartari, & Pittet, 2021).

The term hand hygiene as distinct from handwashing, is now widely used and accepted in healthcare practice and the literature. It denotes the process of reducing the colonisation of the hands by the transient flora that may have been acquired during care activities (Pittet & Boyce, 2001). At a practical level hand hygiene may involve the washing of the hands with either plain soap

or with soap containing anti-microbial or disinfectant product, or the use of an alcohol-based hand rub (ABHR) (Grayson et al., 2018a; WHO, 2009). In the past soap and water washing was considered the usual method of hand cleansing, however with the advent of effective and well tolerated ABHR products, this is now the predominant, and indeed recommended method for most hand hygiene episodes (Grayson et al., 2018a; WHO, 2009). ABHR is seen as advantageous due to the convenience, accessibility, enhanced efficacy, time savings and superior dermal tolerance as compared to soap and water washing (Grayson et al., 2018a; WHO, 2009). In addition, the ample provision of ABHR has been convincingly linked to increased hand hygiene compliance in a number of studies (Boyce & Pittet, 2002; Gordin, Schultz, Huber, & Gill, 2005; Hayden et al., 2006; Hugonnet, Perneger, & Pittet, 2002; Pittet et al., 2000).

CONTEMPORARY TYPES AND MEASURES OF HAND HYGIENE: THE WHO 'MY 5 MOMENTS'

The WHO 'My 5 Moments for Hand Hygiene' evolved out of the WHO First Global Patient Safety Challenge which launched in 2005 and identified hand hygiene promotion as a priority in healthcare (Pittet, Allegranzi, & Boyce, 2009). Further review and refinement saw the development of the WHO Guidelines on Hand Hygiene in Healthcare in 2009 which have been available since 5 May 2009 (Pittet et al., 2009; WHO, 2009).

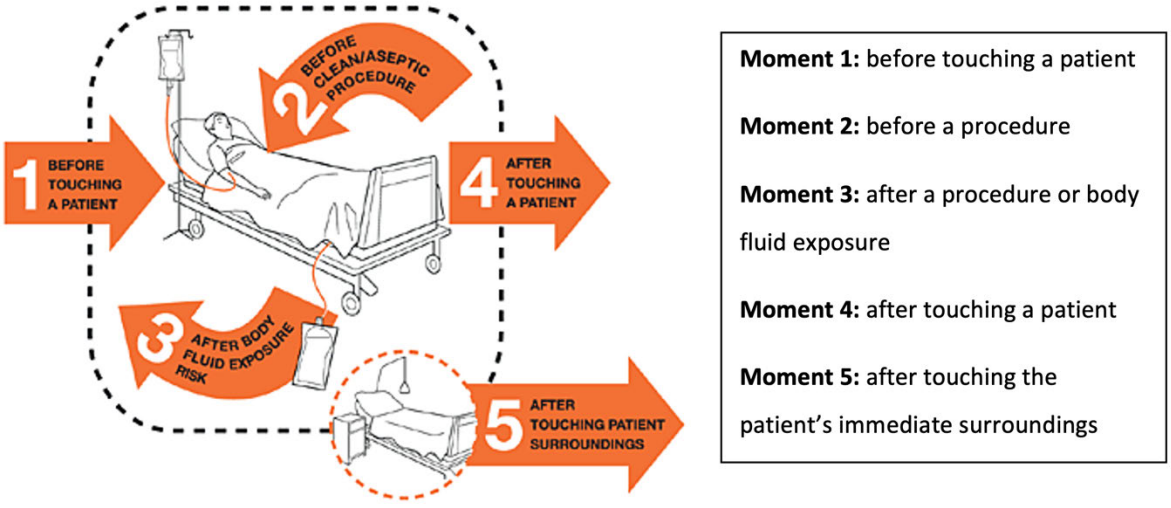


Figure 1. The WHO 'My 5 Moments' for Hand Hygiene (source: https://www.who.int/campaigns/world-hand-hygiene-day).

The guidelines offer a conceptual framework which provides clarity to the HCW as to when they should undertake hand hygiene during patient care interactions in order to interrupt the transmission of microorganisms and minimise the risk of HAIs (Grayson et al., 2018a; Steed et al., 2011; A. J. Stewardson, Sax, Longet-Di Pietro, & Pittet, 2011; WHO, 2009). The WHO My 5 Moments are based on the model of microorganism transmission via the hands as described in Figure 1.

In addition to providing practical instruction on when to perform hand hygiene during the sequence healthcare practice, the guidelines provide a framework and practical tools for the implementation of the changes required to introduce, monitor, maintain and/or improve hand hygiene compliance. This includes education, behaviour change programs, compliance monitoring activities and procedures as well as various implementation and training tools and resources (Boyce, 2011; Grayson et al., 2011; Pittet et al., 2009; WHO, 2009).

According to the My WHO 5 Moments framework, compliance can be defined as the number of times that a HCW actually performs hand hygiene (also known as an event or HHE) divided by the number of times that hand hygiene should have occurred (opportunity or HHO), the result being expressed as a percentage (Grayson et al., 2018a; Kingston, O'Connell, & Dunne, 2016; WHO, 2009). It must be noted however that these hand hygiene events and opportunities must fit within the contextual framework and indications of the 5 Moments rather than being what Sax et al. (2009b) refers to as “complementary” or “facultative” (p. 828) hand hygiene, in that it does not fit the criteria for being classified as a Moment according to the WHO guidelines.

While the WHO My 5 Moments are universally known and accepted as the gold standard for performance of hand hygiene (Pittet et al., 2009), this framework does not have universal application in terms of a compliance monitoring metric (Doron et al., 2011; Kingston et al., 2016). Armellino et al. (2012) note that there is no “recognised standard” (p. 5) for monitoring hand hygiene compliance. Indeed various compliance frameworks are used and reported in the literature, although it would appear that 2 predominate, the first being the WHO My 5 Moments, or minor variations such as the adaption to ‘4 Moments’ in Canada (Lebovic, Siddiqui, & Muller, 2013). The alternative method involves the use of proxy or surrogate measures variously referred to as; room entry/exit hand hygiene, the in/out method or wash in/wash out hand hygiene (Diller et al., 2013; Masroor, Doll, Stevens, & Bearman, 2017; Sunkesula, Kundrapu, & Donskey, 2015). Essentially this metric involves the performance of hand hygiene upon entry to and exit from the patient zone or room. The justification for the latter approach over the WHO My 5 Moments is that such data collection methods are simpler, more sustainable and that the information is less intrusive to gather (Y. C. Chen et al., 2011; Dufour et al., 2017; A. J. Stewardson et al., 2011; Talbot et al., 2013).

Unfortunately, the lack of uniformity in compliance monitoring methodology means that data from different states, jurisdictions and/or countries may not be comparable. This is one reason why proponents of the WHO My 5 Moments support the universal application of this compliance monitoring framework (Grayson et al., 2018a).

MEASURING AND MONITORING HAND HYGIENE COMPLIANCE

The recommendation to monitor hand hygiene adherence is a key element of the WHO Guidelines (WHO, 2009). This recommendation has been adopted to a greater or lesser degree worldwide. Ontario, for example, has required mandatory monitoring and reporting of hand hygiene compliance since 2009 (Lebovic et al., 2013). In Australia, monitoring of hand hygiene is enshrined in national healthcare standards which mandate that a healthcare service has a hand hygiene program that is "consistent with current National Hand Hygiene Initiative and jurisdictional requirements" (Australian Commission on Safety and Quality in Health Care, 2017, p. 25). The National Hand Hygiene Initiative (NHHI) is an obligatory national hand hygiene program originally administered by Hand Hygiene Australia (HHA). Hand hygiene compliance monitoring became required by all public hospitals in Australia in 2010 under the auspices of the NHHI (Azim & McLaws, 2014; Grayson et al., 2018a; Kwok, Juergens, & McLaws, 2016). From 1 November 2019 oversite was transferred to the Australian Commission on Safety and Quality in Health Care (ACSQHC) which now coordinates and supports all aspects of the NHHI.

The NHHI 5 Moments for Hand Hygiene Guidelines stipulate that compliance is measured using the 5 Moments framework and further, that specified quantities of data, in the form of a set number of Moments, according to facility size, acuity, bed numbers and/or procedures performed, are submitted to the national body three times each year (Azim, Juergens, Hines, & McLaws, 2016; Grayson et al., 2018a). National compliance thresholds are set by meetings of states and territories and data is available for scrutiny in the public domain via the MyHospitals website- https://www.myhospitals.gov.au/ (Cruickshank, 2018; McLaws & Kwok, 2018). The NHHI is seen as a "world leading national program" (Cruickshank, 2018, p. 1) with the stated primary aim being to "improve hand hygiene compliance among HCWs and to reduce transmission of infection in healthcare settings throughout Australia" (Grayson et al., 2018a, p. 14).

Compliance monitoring is a vital part of any behaviour change program, as Larson (2013) notes, "ultimately, the goal of any monitoring is to improve performance" (p. 42) and this is clearly one of the anticipated outcome of measurement of compliance. Determining HCW adherence to hand hygiene guidelines is seen as an essential and integral part of any successful hand hygiene program (Boyce, 2008; L. F. Chen et al., 2013; Srigley, Lightfoot, Fernie, Gardam, & Muller, 2013).

Monitoring compliance provides baseline data against which the impact, successful or otherwise, of any hand hygiene improvement programs, may be evaluated (Cantrel, 2016; Conway, 2016; Masroor et al., 2017; Pincock, Bernstein, Warthman, & Holst, 2012). The process of hand hygiene compliance monitoring also provides information as to specific gaps in HCW knowledge and behaviour. This information can, in turn, be used to inform and more specifically target education and behaviour change programs as part of ongoing compliance improvement strategies. Without contextual information as to why hand hygiene is not being performed it is difficult to plan and implement programs to remedy the situation (Boyce, 2011; Boyce, Cooper, & Dolan, 2009; Conway, 2016; Conway et al., 2014; Stackelroth & Shaban, 2011). Measuring compliance also provides data which can serve as a quality indicator for healthcare facilities. It can be compulsory, as part of mandated jurisdictional submission requirements, may provide data for benchmarking between hospitals, regions or states and may also help infrastructure design through identification of workflow patterns and the optimal placement of hand washing and ABHR facilities (Boyce, 2011; B. I. Braun, Kusek, & Larson, 2009; Edmisten et al., 2017; El-Saed et al., 2018; Kwok et al., 2016; Sax et al., 2009b).

DIRECT OBSERVATION – THE 'GOLD STANDARD' FOR COMPLIANCE MONITORING

The WHO Guidelines on Hand Hygiene in Health Care (2009) recommend that the "detection of hand hygiene compliance" (p. 158) be performed using the direct observation method. This method is also referred to as, observational surveys, visual auditing, the observation method, the secret shopper method, direct human auditing or in-person observation (Boyce, 2008; Cantrel, 2016; Pickering, Blum, Breiman, Ram, & Davis, 2014; Pittet et al., 2009; Storey et al., 2014). Direct observation is considered the gold standard of hand hygiene compliance data collection (Boyce, 2008; Geilleit et al., 2018; Grayson et al., 2018a; Hagel et al., 2015; A. J. Stewardson et al., 2011; WHO, 2009). It is reported as the most commonly used method of compliance monitoring and is also described as being the traditional, the most favoured and the most widely accepted technique for hand hygiene compliance auditing which has almost universal applicability in nearly any healthcare setting (Cantrel, 2016; Dhar et al., 2010; Srigley, Furness, Baker, & Gardam, 2014).

The WHO guidelines highlight the importance of using validated auditors to perform direct observational auditing and the document goes on to outline suggestions for training and validation processes (WHO, 2009). Internationally, there would appear to be a lack of consistency in the uptake of the suggested auditor validation process. For example, in a study by Doron et al. (2011) auditors received 45-60 minutes of instruction prior to collecting hand hygiene compliance data, while an international survey of Infection Prevention and Control Practitioners conducted by B. I. Braun et al. (2009) found that 65% of respondents reported providing less than one hour of training to their

auditors. Direct observation in the Australian context is covered by the NHHI mandate and involves data being collected by auditors who have completed an endorsed and standardised hand hygiene auditor training program of approximately eight hours, and which includes two separate competency assessment tasks. This is in line with the WHO recommendation and aims to ensure that all auditors collect data in a standardized manner. In addition, auditors are required to maintain competency by auditing a minimum number of Moments per year and completing an annual revalidation assessment (Care, 2019; Grayson et al., 2018a).

On a practical level, direct observation involves the auditor being present in the clinical environment where they observe HCW practice and care interactions while recording all hand hygiene opportunities or Moments and whether they were correctly undertaken or missed (D. J. Gould et al., 2017; Hagel et al., 2015; McGurkin & Govednik, 2015; Srigley et al., 2014). As Brotfain et al. (2017) notes, the observer is required to "stand in proximity" to the HCW, but not to "interfere with their activity" (p. 850). The compliance rate is expressed as the percentage calculated by dividing the number of correctly performed hand hygiene Moments by the number of times that hand hygiene should have occurred according to the WHO My 5 Moment framework. The current benchmark in Australia is 80% (Grayson et al., 2018a; WHO, 2009).

ADVANTAGES OF DIRECT OBSERVATION

Direct observation has many advantages being able to provide "substantial information on compliance behaviour" (Venkatesh et al., 2008, p. 199). Chief among its attributes is the ability to assess and calculate compliance with all 5 of the WHO Moments for hand hygiene (Arai et al., 2016; Boyce, 2011; Edmisten et al., 2017; Hagel et al., 2015). Indeed Boyce (2017b) asserts that of all hand hygiene compliance measuring modalities, including the electronic monitoring systems discussed in Chapter 2, direct observation has the unique ability to provide compliance rates to the level of detail required by the WHO criteria. It is contended that awareness of compliance with all 5 of the Moments is important. As Haas and Larson (2007) note, "patients don't benefit from partial compliance" (p. 8). By being able to monitor hand hygiene according to the WHO 5 Moments, auditors are able to establish whether hand hygiene is occurring at the correct time during the care episode (Boyce, 2008; Boyce, Polgreen, Monsalve, Macinga, & Arbogast, 2017; Morgan et al., 2012), which in turn represents optimal practice in terms of the reduction in microbial transmission.

Another advantage is that the context of noncompliance may be established, that is, at what point in the care sequence is hand hygiene not performed (Morgan et al., 2012; Sax et al., 2009b), which Moments are being missed and in what specific situations. Conway et al. (2014) concur, citing the difficulties in planning behaviour change interventions without "contextual information about

noncompliance" (p. 415). Even those critical of the direct observation methodology, such as Srigley et al. (2015) who describes it as a "flawed metric" (p. 58) acknowledge that it is the only method to directly link hand hygiene events to HWC contact with patients and their environment.

Direct observation also allows the compliance data gathered to be differentiated according to HCW group, designation or category (Boyce, 2008; Hagel et al., 2015). It is therefore possible to establish which HCW groups are or are not performing hand hygiene appropriately and to tailor redemptive strategies specifically to that population (Arai et al., 2016; Haas & Larson, 2007). Furthermore, auditors can identify specific individuals who are noncompliant and provide education and support (D. J. Gould et al., 2017). This can be especially pertinent if compliance in a particular department or team is generally satisfactory, but the behaviour of an outlier is affecting overall results. Additionally, hand hygiene performed by visitors and patients can be excluded, which may not be possible with some product consumption or electronic measurement methods (Srigley et al., 2013) as will be discussed.

Although not formally audited according to the WHO My 5 Moment framework, direct observation can also provide detailed information as to hand hygiene technique, or the so-called "qualitative elements" (Korhonen et al., 2015, p. 3199) of hand hygiene performance (Hagel et al., 2015; Pan et al., 2013). A number of authors argue that hand hygiene technique may be just as, if not more, important than frequency and further, that focus should be on better hand hygiene rather than simply more hand hygiene. Hence, the importance of an awareness of adherence to correct technique is clear (Korhonen et al., 2015; Larson, Early, Cloonan, Sugrue, & Parides, 2000).

The direct observation process allows for the assessment of glove use or misuse and its impact on hand hygiene compliance (Boyce et al., 2017). Inappropriate glove use has been reported to be convincingly linked to poor hand hygiene compliance in a number of studies and systematic reviews (Grayson et al., 2018a; WHO, 2009). Direct observation allows auditors to identify the adverse impacts of glove use on hand hygiene compliance and to provide corrective advice or education.

The adjunctive information gathered during direct observational auditing is able to be utilised in the formulation of compliance improvement strategies which are tailored to the specific areas of need that have been identified. Anecdotal reports from auditors along with compliance data will help to pinpoint any themes or patterns of noncompliance which may apply to specific situations, care tasks, departments or HCW groups (Boyce, 2011; Haas & Larson, 2007; Hagel et al., 2015). This information can in turn be used to design and implement behaviour change and educational programs specifically targeted to correct particular knowledge deficits, with specific

audiences. It can also be used to identify and subsequently address infrastructure issues such as product placement or availability which may be contributing to poor adherence to hand hygiene guidelines (Boyce, 2017b; D. J. Gould et al., 2011; Pires & Pittet, 2017). As Haas and Larson (2007) note; “knowing more specifically where an intervention is needed can allow institutions to more specifically target resources to their particular problems” (p. 7). This can be particularly pertinent in resource limited settings where achieving maximal impact from an intervention is critical and hence limited resources are not squandered in an attempt to rectify a general issue of noncompliance based on a poor ‘score’ but are rather focused on correcting specific issues.

Direct observation is a relatively simple audit methodology which can be implemented in a variety of settings and adapted to many and varied contexts (Boyce et al., 2017; WHO, 2009). It is seen as a low-cost approach that is not dependent on expensive technology or infrastructure making the method ideal for resource limited settings, particularly those with restricted infrastructure or technological assets but with high levels of human capital (Boyce et al., 2017; Masroor et al., 2017).

The presence of a hand hygiene auditor in the clinical setting performing direct observational auditing also reinforces the importance of hand hygiene as a quality patient safety activity and the significance with which compliance is regarded by the healthcare institution. It clearly demonstrates managerial and administrative support for the practice, raises awareness of hand hygiene, as well as serving as a reminder to frontline HCWs (Kwok et al., 2016; Pan et al., 2013; Wiemken et al., 2018). D. J. Gould et al. (2017) also noted that by performing direct observational audits Infection Prevention personnel will gain “an idea of what is taking place in clinical areas” (p. 172). This “what is taking place” may or may not relate to hand hygiene behaviours but will undoubtedly provide useful information.

Another much cited benefit of direct observation is the ability of the auditor to provide performance feedback to the HCWs who are the subject of the audit (Boyce et al., 2017; Hagel et al., 2015; Pan et al., 2013). Provision of feedback is seen as an essential aspect of any multimodal hand hygiene improvement program. Wiemken et al. (2018) go so far as to states that it is a “critical prerequisite to any intervention for improving hand hygiene ”(p. 617). Feedback has been convincingly linked to improvements in compliance with many audited healthcare metrics, particularly hand hygiene, in a number of studies and systematic reviews (Fuller et al., 2012; Levchenko, Boscart, & Fernie, 2014; Overdyk et al., 2016; Storey et al., 2014; WHO, 2009). Armellino et al. (2012) highlight the importance of feedback in sustaining a high level of compliance while Boyce (2017) emphasises the importance of “real time coaching” (p. 529) in improving practice.

Feedback is seen as having both cueing and motivational effects on behaviours, in that giving specific feedback to individuals may mean that they can change and improve their practice and is thus a stimulus to compliance (Pan et al., 2013; Parsons, 1974; Pires & Pittet, 2017). As Parsons (1974) notes, "behaviour is a function of past reinforcement" (p. 929) suggesting that the provision of feedback can reinforce correct behaviour. Feedback can also assist HCWs to gain insight into their own practice, as, according to Larson et al. (2000), many HCWs believe or self-report a much higher level of hand hygiene compliance than is observed using other methods, such as direct observation. Hence, the information provided by feedback of practice may assist in self-reflection and improvement. Work by Kruger (1999) identified that the less competent an individual is at a particular activity, the less likely they are able to self-identify a lack of competence. Indeed, participants in their study who scored in the lowest percentile were most likely to overestimate their abilities in some cases by up to 54 percentage points. Essentially, it can be argued that if HCWs are unaware of their level of compliance and the specific areas of correct and incorrect practice, it is difficult, if not impossible for them to change their behaviour.

Group feedback may also be offered as a result of direct observational auditing and can serve to enhance a sense of group identity and cohesion and can promote improved compliance through a beneficial sense of competitiveness between groups (Sax et al., 2009b). However, Conway et al. (2014) does warn that group feedback can be less effective than personal feedback in terms of correcting noncompliant behaviour, possibly due to the decreased individual accountability inherent in group result reporting, however there are benefits to both individual and group feedback approaches.

While the presence of the auditor in the clinical setting and the provision of immediate feedback is seen as advantageous due to the positive effect upon compliance, there are also notable limitations and disadvantages. These relate not only to the behavioural changes induced by the presence of the auditor, but also to the method as a whole, as discussed next.

DISADVANTAGES OF DIRECT OBSERVATION

Perhaps the most frequently cited failing of the direct observation method is the impact that what is known as the Hawthorne Effect has on the accuracy of compliance data collected in this manner. D. J. Gould et al. (2017) go so far as to suggest that the Hawthorne Effect is in fact "the most serious criticism" of direct observation as a compliance monitoring technique.

Although the Hawthorne Effect was not formally described until the 1950s, the name relates to a series of 7 productivity studies which took place at the Western Electric Company Plant near

Hawthorne, Chicago between 1924 and 1932 (Haessler, 2014; Parsons, 1974). These experiments involved the provision and removal of a series of conditions for a select group of 5 women housed in a special room away from the main workforce. The popular interpretation has been that it was participation in the experiment itself rather than any of the other experimental factors that resulted in the enhanced productivity (D. J. Gould, Chudleigh, Drey, & Moralejo, 2007; D. J. Gould et al., 2017; Parsons, 1974). However, this "basic interpretation" (Haessler, 2014, p. 1) has since been questioned and there are suggestions of an effect relating more to consequences achieved through feedback. Jones (1992) suggests that the observed productivity effects were due to enhanced teamwork or social cohesion among the members of the experimental group and also highlights the impact of the "special attention" (p. 457) that the participants received. J. D. Holden (2001) adds the possibility of morale, attitude and operant conditioning as being responsible for the changes documented in the Hawthorne experiments. Berthelot, Le Goff, and Maugars (2011) warn that the Hawthorne Effect can also be confused with the placebo effect or potentially with the Pygmalion effect which manifests when the evaluator is "particularly likeable" (p. 335) and the participant is driven by the desire to please or to meet perceived expectations. It is also hypothesized that what we have come to call the Hawthorne Effect is in fact a complex interaction of the impacts of being the subject of audit or data collection and factors such as the "psychological impact of being watched, singled out, noticed or made to feel important" (Hagel et al., 2015, p. 957).

Another factor to consider in terms of behaviour change due to the presence of the auditor is the impact of social power or influence. French and Raven (1959) discuss 5 aspects or bases of social power that have the ability to influence behaviour. These bases include reward power, where the subject changes their behaviour to either achieve a reward or advantage along with coercive power where behaviour change is aimed at avoiding punishment or the consequences of noncompliance. There is also legitimate power which may relate to the cultural beliefs of the subject or their acceptance of the prevailing social structure of organisational hierarchy such that they believe that others have legitimate right to prescribe behaviour for them and it is their role to comply. Referent power relates to a desire in a subject to identify with or be respected by another and expert power relates to the belief that the perceived expert has greater skills, knowledge or expertise than the subject. According to Rex, Hewett, Raghavendra, and Chalasani (2010) in the context of auditing HCW practice and behaviours it is expert, referent and coercive power that is most likely to influence behaviour and mediate change. However, it could be argued for the potential for all 5 bases to have a contribution. Staff being audited may change behaviour in order to receive praise and positive approbation (reward power) or avoid reprimand or a poor appraisal (coercive power). They may feel that the auditor has the right or authority to correct their practice

(legitimate power), they may aspire to become an auditor or gain the approval and respect of the auditor (referent power), or they may believe that the auditor has greater knowledge than they do (expert power). In addition, elements such as peer pressure, social power, role modelling and the follower effect are also believed to be responsible for hand hygiene behaviour changes associated with the presence of an observer (Dufour et al., 2017; D. J. Gould et al., 2017; Haessler, Bhagavan, Kleppel, Hinchey, & Visintainer, 2012; Kwok et al., 2017).

Notwithstanding what has gone before, or even what occurred during the original experiments, the term 'Hawthorne Effect' has now come to be defined, particularly in the hand hygiene context, as the tendency of individuals to alter their behaviour when they become aware that they are being studied, observed or in some way directly visualised. The phenomenon is also referred to as observation bias, information bias or measurement reactivity (Berthelot et al., 2011; N. A. Brown, Blake, & Sherman, 2017; L. F. Chen et al., 2013; Daniels, 2012; Doron et al., 2011; Jeanes, Coen, Gould, & Drey, 2019; Kohli et al., 2009; Srigley et al., 2014). Essentially, the outcome is a change in behaviour and hence the collection of biased data as a consequence of the act of being observed.

Whatever the precise mechanism of effect, it is generally accepted that referencing the Hawthorne Effect in relation to direct observational auditing implies that there has been a transient increase in hand hygiene compliance as a consequence of the presence of the auditor who is gathering the data (Boyce, 2017b; Kwok et al., 2016; Srigley et al., 2013). While this has previously been seen as a positive benefit of the direct observation methodology, it is increasingly recognised that the rise in hand hygiene compliance is highly dependent on the physical presence of an auditor. For example, Srigley et al. (2014) reports a significant upward spike in the performance of hand hygiene which coincided with the commencement of direct observational hand hygiene auditing as compared to the rate in the 15 minutes prior to the auditor's arrival. This increase, however, only occurred at hand hygiene dispensers directly within the visual field of the auditor. During a study by Filho et al. (2014) an increase in hand hygiene was also noted when an auditor was present and performing direct observational auditing. During the hour that the auditing occurred the hand hygiene performance rate rose by 37.3% as compared to the hour prior to the auditor's arrival and perhaps more significantly a decrease of 53.3% was reported for the hour following the auditor's departure. Participants in a study by Mackrill, Dawson, Garvey, and Gould (2017) note how auditors reported that often staff "perform for us" (p. 24) reflecting on how the presence of an auditor in the clinical space effects hand hygiene behaviour. While one of those interviewed by Dawson (2015) gave a very strongly worded response, referring to the Hawthorne Effect impacts on data as "…corrupt" and going on to note, "These HH (sic) audits… there's nothing valid about them" (p. 253).

Various attempts have been made to quantify the impact of the Hawthorne Effect on hand hygiene compliance rates, presumably so that an adjustment could be made in order to allow the calculation of the 'true' rate of compliance. Grayson (ACIPCLIST, 2018), for example, suggests that the Hawthorne Effect causes an increase in compliance of approximately 7%. McLaws and Kwok (2018), on the other hand, places the impact at between 20 and 50 percentage points or between 1.3 and 3.1 times the true rate. Diller et al. (2014) suggest a 30% effect, while Eckmanns, Bessert, Behnke, Gastmeier, and Ruden (2006) places the impact as high as 55% seeing an increase from an average of 9.4 hand hygiene episodes per hour to 18.7 episodes per hour when the auditor was present. Hagel et al. (2015), found an impact of three times the 'normal' rate, but cautioned against simply dividing hand hygiene compliance rates recorded by direct observation by three to ascertain the "true" rate. Rather, they suggested a variable impact of the Hawthorne Effect as a result of a multiplicity of factors.

Who performs the direct observation and how obvious, overt or visible they are will also affect the extent to which the Hawthorne Effect raises compliance (Berthelot et al., 2011; Boyce, 2017a; D. J. Gould et al., 2017; Knighton & Davis, 2018; Pan et al., 2013). The mere presence of a fellow HCW in the clinical area has also been noted to increase hand hygiene, with progressive rises in compliance recorded as the number of individuals present in the clinical space increases and the HCW is able to be visualised by colleagues (Monsalve et al., 2014).

The duration of the auditing episode will also affect the degree to which the Hawthorn Effect raises compliance rates. L. F. Chen et al. (2013) found that the longer the auditor continued auditing the higher the rates of hand hygiene compliance became, presumably as the "news of their presence is progressively spread throughout the unit" (p. 208).

While most authors focus on the inflation of compliance measured by direct observation as a consequence of the Hawthorne Effect, D. J. Gould et al. (2017) cautions that "awareness of being watched can disrupt the normal behaviour in complex and unpredictable ways other than simple productivity effect" (p. 9). Gould goes on to suggest that HCWs, once they are aware of being observed, may relocate care activities to avoid scrutiny or postpone the patient care until the auditor has left, both of which will result in non-representative data and may even place the patient at risk due to treatment delays. An example of this is illustrated in a novel study undertaken by Moller-Sorensen, Korshin, Morgensen, and Hoiby (2016), where the installation of hand hygiene monitoring and reminder technology in staff toilets saw staff usage of one monitored restroom drop to one third of baseline during the intervention phase. It was suggested that HCWs used other facilities as a way to avoid being monitored.

Various suggestions have been made as to how to ameliorate the impact of the Hawthorne Effect with covert, discrete, unobtrusive or even secret auditing being foremost among recommended practices identified as having been convincingly linked to the capture of lower rates of compliance, and presumably more naturalistic hand hygiene behaviour (D. J. Gould et al., 2017; Knighton & Davis, 2018; Kohli et al., 2009; McLaws & Kwok, 2018). Some authors do however recommend against less than overt auditing tactics on the basis that it is unethical and can engender mistrust, particularly given that the auditor will eventually be detected (D. J. Gould et al., 2017; Hagel et al., 2015). Sax et al. (2007) suggests that the Hawthorne Effect can be avoided by the auditor "not being too obvious, while not deceiving the observed HCW about the purpose of the observation" (p. 832). Confusingly, this suggestion follows almost immediately after an injunction to the auditor to ensure that they introduce themselves to both the HCW and the patient and to "indicate unobtrusively the reason for his or her presence" (p. 832), which, it would be suggested, makes the avoidance of the Hawthorne Effect unlikely. Masroor et al. (2017) highlights another problem with covert auditing, where in order to collect accurate data about all hand hygiene opportunities the auditor must be positioned so as to be able to accurately visualise the care interactions that would clearly make remaining unobtrusive next to impossible. Another strategy akin to covert observation is to use unknown or unfamiliar auditors, ideally in combination with covert or at least discrete observation practice. This may include the use of volunteers, HCW students or the practice of rotating peer or local auditors to departments other than their own (Boyce, 2017a; L. F. Chen et al., 2013; Harbarth et al., 2002; McDonald, Smyth, Smyth, & Lee, 2018; Sax et al., 2009b).

Performing audits at random or unannounced times has also been suggested, as well as limiting the duration of the audit session (Harbarth et al., 2002; Pittet et al., 2000). Sax et al. (2007) recommend 20 +/- 10 minutes as the optimal time for an auditing session. However, shorter audit sessions are recommended on the basis of several studies which demonstrated that the Hawthorne Effect mediated compliance increase was detected after 10 (L. F. Chen et al., 2013) to 15 (Yin et al., 2014) minutes and hence it is postulated that limiting audits to this duration can reduce the likelihood of bias. It is interesting to note that the recent systematic review undertaken by Jeanes et al. (2019) found that in 16 out of 71 studies (23%) observation periods of greater than 1 hour were used to collect data via direct observation.

An alternative approach is to audit more frequently and openly with the aim of reducing the Hawthorne Effect by acclimatisation or habituation of the HCWs to the presence of the auditor (El-Saed et al., 2018; D. J. Gould et al., 2017). It is worth noting however that the results of a study by Harbarth et al. (2002) suggest that it took approximately 2 weeks for compliance rates to drop and

for staff to become less aware of the presence of the auditor, presumably demonstrating the "waning of the Hawthorne Effect" (Harbarth et al., 2002, p. 489).

Another common criticism of direct observation is that it constitutes a time consuming and labour-intensive way to collect data (Boyce et al., 2009; Fisher et al., 2013; Hagel et al., 2015; Wiemken et al., 2018). The requirement for such a significant "investment in human capitol" (Daniels, 2012, p. 1488) imposes burdens on staff who may have competing clinical or administrative roles, hence making direct observational auditing difficult to maintain (Gilbert, 2014; Stackelroth & Shaban, 2011; Storey et al., 2014; Yin et al., 2014). The excessive workload may also preclude the gathering of large amounts of data such that samples may be statistically underpowered (Daniels, 2012; Marra, Moura, Paes, dos Santos, & Edmond, 2010). Azim and McLaws (2014) suggest that on average it takes 2.2 minutes to collect each Moment, which would translate to approximately 320 hours of auditor time per hospital per audit period. Based upon the figure of 2.2 minutes per Moment and the data from the NHHI administrator platform (https://nhhi.safetyandquality.gov.au/en_AU/NHHI/dashboard - accessed 8 April 2022) there are indications that data collection for the national auditing program in Australia has, over the last 4 years, consumed an average of 72,000 hours of auditor time per annum (Table 1).

Related to the time taken to collect hand hygiene compliance data via direct observation is the expense of the process. Although direct observation is often described in the literature as an inexpensive methodology, particularly in comparison to electronic monitoring measures, the claims are increasingly scrutinised due to the fact that most data is collected by nurses or other similarly 'expensive' health professionals (Morgan et al., 2012). The study by Azim and McLaws in 2014, suggested that the annual cost of collecting the NHHI mandated data via direct observation was approximately AU$2.2 million p.a. or an average of AU$16,000 per hospital per audit. Utilising more recent data from the NHHI database and the parameters suggested by Azim and McLaws would indicate that the cost has increased to between AU$3.4 – 3.7 million per annum.

Table 1. Moments collected and submitted to the NHHI from 2018 to 2021. Calculations are based on figures suggested by Azim & McLaws (2014): 2.2 minutes per Moment and a AU$50 per hour auditor wage.

	Total Moments per annum (Australia)	Total time (hours)	Total cost (AU$)
2018	1,993,141	73,082	3,654,091.83
2019	2,033,475	74,561	3,728,037.50
2020	1,857,539	68,110	3,405,488.17
2021	1,962,068	71,942	3,597,124.67

In addition to the cost of collecting hand hygiene Moments there are also numerous associated expenses, including the original training of hand hygiene auditors as well as the ongoing need for additional auditors to replace those lost by attrition. There are also costs associated with program administrative oversight and logistics which are often borne by Infection Prevention and Control Services (IPAC) (Azim et al., 2016; Boyce, 2017b; Diller et al., 2014; Geilleit et al., 2018). Morgan et al. (2012) also cite "opportunity costs" (p. 956) in that, other activities may be foregone to allow auditing. Some authors believe however that the true cost of the direct observation method is the fact that precious time and resources are utilised to collect data which is inherently inaccurate and potentially misleading (Kwok et al., 2016).

Another criticism of direct observation is that quality of the data is impacted skill of the auditor or auditors who actually undertake the data collection, making the final results potentially questionable. Consistency of auditor training is addressed in the Australian context with the program originally outlined by HHA being utilised nationally (Grayson et al., 2008). However, this is not the case internationally with reports of auditor training ranging from as brief as 20 minutes instruction up to three hours duration in contrast to the mandated eight-hour program within the NHHI auditor framework (Boyce, 2011, 2017b; B. I. Braun et al., 2009; Conway, 2016; Grayson et al., 2018a). The systematic review conducted by Jeanes et al. (2019) found that auditors received training in only 77% of the 71 reported studies included in the review and further that the specific method of training was detailed in only 23% of studies. The need for ongoing support, retraining and validation of auditors is also highlighted in the literature (D. J. Gould et al., 2011; Haas & Larson, 2007) and this is pertinent given that data is often collected by multiple auditors who have the potential to interpret the guidelines differently despite consistent training (Azim et al., 2016; D. J. Gould et al., 2011; van de Mortel & Murgo, 2006).

The specific individual performing the audit has also been shown to impact on the results. The majority of auditing is performed by either IPAC professionals or local ward level or peer auditors, most commonly nurses (Boyce, 2008; D. J. Gould et al., 2011). Data collected by local ward auditors has been identified as being particularly suspect. A study by Dhar et al. (2010) suggested that local auditors were more than two times more likely to report hand hygiene practice as compliant as compared to IPAC professionals. Similarly, McLaws and Kwok (2018) reported a 20 percentage point difference between results obtained by local auditors and those of IPAC auditors. It is suggested that this discrepancy is due to ward peer auditors' local allegiances to their colleagues (Dhar et al., 2010; McDonald et al., 2018) or being what Morgan et al. (2012) describes as

"potentially partial observers" (p. 955). Pan et al. (2013) suggests that local auditors may have an "apparent inability or unwillingness to detect poor compliance" (p. 5) which Rosenthal, Guzman, and Safdar (2005) argues is due to hectic work schedules and competing demands. Mahida (2016) points out that high targets with associated penalties for noncompliance may act as a "perverse incentive" (p. 307) to report high compliance rates but that these results are rarely able to be replicated or validated in audits performed by Infection Prevention and Control staff. Morgan et al. (2012) goes so far as to suggest that local auditors "may have a stake in reporting higher compliance rates, resulting in intentional or unintentional bias" (p. 956). Diefenbacher, Sassenrath, Tatzel, and Keller (2020) also suggest the possibility of the impact of 'leniency bias', sometimes referred to as the 'alliance effect' (Jeanes, Coen, Wilson, Drey, & Gould, 2015) where local auditors are reluctant to report poor compliance in their own unit, ward or department.

It is also important to consider that hand hygiene auditing is a complex, demanding and skilled activity which cannot, or more pertinently, should not, be maintained for any length of time if the occurrence of fatigue, errors and subsequent data loss are to be avoided (B. I. Braun et al., 2009; D. J. Gould et al., 2011; McGurkin & Govednik, 2015). However, as has also been noted, while some auditing sessions are brief at around 10 – 30 minutes, others are reported to extend for several hours making the data collected of questionable accuracy (Boyce, 2008, 2017b; Fries et al., 2012; McLaws & Kwok, 2018).

Direct observational auditing is criticised as providing only labour-intensive snapshots of hand hygiene practice, which may not accurately represent overall hand hygiene behaviour across a department or facility (Fisher et al., 2013; Masroor et al., 2017). Such small samples are most likely a consequence of the time-consuming nature of data gathering by direct observation (Marra et al., 2010). However, these low numbers may result in the disproportionate skewing of the data as a consequence of the behaviour of compliance outliers, be they high or low performing. This in turn leads to questions about the statistical validity of the results, which may therefore be deemed to be subject to both systematic and random errors (Hagel et al., 2015; van de Mortel & Murgo, 2006). Attempts have been made to quantify the proportion of Moments captured by direct observation as compared to the overall hand hygiene Moments occurring. van de Mortel and Murgo (2006) suggest that 0.4% of Moments occurring were captured by the direct observation method used in their study. Alper (2015) cites a figure of <1%, Marra et al. (2010) reports 1.3%, while in a systematic review Boyce (2011) cites a range of between 1 and 3% of all hand hygiene opportunities occurring. In addition, Morgan et al. (2012) argues that such small samples are insufficiently sensitive, meaning that as a result, institutions can fail to detect changes and trends in hand hygiene compliance or fail to do so in a timely manner.

Another potential problem with data collected using direct observation is that of selection bias, or what is also referred to as sampling or ascertainment bias (Azim et al., 2016; L. F. Chen et al., 2013; Jeanes et al., 2019). Selection bias occurs when auditors preferentially sample at certain times of the day, at certain locations and/or consciously or unconsciously record the behaviour of particular HCW groups or individuals (Azim et al., 2016; Grayson et al., 2018a; McLaws & Kwok, 2018). Such decisions may result in a non-representative sample and hence once again, results that do not reflect overall hand hygiene behaviours. All 71 studies reviewed by Jeanes et al. (2019) showed evidence of selection bias, suggesting the problem is common and further calling into question the validity of data collected by the direct observational methodology.

Observer bias is another form of bias attributed to data collection using direct observation. Although the NHHI guidelines and auditor training framework have been created in an attempt to minimise this issue (Care, 2019) the problem is still noted as a potential confounder, particularly in international studies (Y. C. Chen et al., 2011; Fries et al., 2012). In terms of hand hygiene auditing, observer bias is deemed to occur when an auditor holds a belief or expectation (be it conscious or unconscious) that a certain HCW or HCW group will or will not perform hand hygiene in a particular situation. These beliefs may impact on the auditor's perceptions and interpretations of the observed hand hygiene behaviours and potentially even the HCWs or HCW groups they select to audit. This in turn, will theoretically affect the reported compliance rates (van de Mortel & Murgo, 2006). Judgements, argue Yeates, O'Neill, Mann, and Eva (2013), are "conducted within a social context and can be influenced by (amongst other things) the assessor's disposition, the purpose of the assessment, and the relationship between the trainee and the assessor" (p. 327).

Another problem attributed to data collected via direct observation is that specific collection and practice techniques, as well as definitions of what constitutes compliance may vary considerably among, not only institutions but between individuals within the same facility (Boyce, 2017b; Morgan et al., 2012). While the WHO (2009) guidelines on Hand Hygiene in Healthcare do provide relatively explicit instructions as to how to undertake direct observational auditing of hand hygiene, this is not an internationally mandated practice and there are numerous examples of modifications to the process and to how compliance is defined, in the literature (L. F. Chen et al., 2013; Jeanes et al., 2019; Talbot et al., 2013). Even in the Australian context where data collection and compliance metrics have been rigorously outlined as part of the National Healthcare Standards (Australian Commission on Safety and Quality in Health Care, 2017) there is still the possibility of individual differences in the interpretations of the definitions of compliance. The phenomenon is sometimes referred to as 'observer drift' (Diefenbacher et al., 2020; Jeanes et al., 2015) and is deemed to occur when an auditor gradually becomes inconsistent with, or changes their application of, recognised

auditing criteria. In addition, an auditor's results may be affected by what Dagnaes-Hansen et al. (2018) refer to as 'anchoring bias' where the auditor holds a previously determined opinion of the HCW subject to audit. Consequently, results may be impacted by an emotional reaction, as opposed to being an objective assessment. Similarly, the 'halo effect' may impact on the reliability of the data. This is said to occur when the results of one auditing assessment impacts upon or influences subsequent ones (Downing & Haladyna, 2004; Ghaderi et al., 2015).

Collection of hand hygiene compliance data by direct observation may be impaired or impeded by physical barriers such as distance from the HCW performing hand hygiene or an obstructed view due to closed doors or bedside curtains (Boyce, 2017b; D. J. Gould et al., 2017; D. J. Gould et al., 2011; Storey et al., 2014). Privacy is usually cited as the reason for closed doors or drawn curtains and why auditors do not intrude to capture the entire care episode (Diller et al., 2014). However, while this may be a valid rationale, the desire to avoid violating patient privacy is often cited as another problem associated with direct observation. By missing activity occurring behind closed curtains, auditors may be failing to capture a subset of data that has the potential to alter compliance rates overall (D. J. Gould et al., 2007; D. J. Gould et al., 2017; D. J. Gould et al., 2011). As this issue means that a proportion of hand hygiene opportunities will not be recorded, this again raises the concern as to the problem of potentially skewed data (Larson, 2013; Marra et al., 2010).

Ethical dilemmas may also arise during direct observation, particularly if a covert or secret auditing approach is utilised (D. J. Gould et al., 2011; van de Mortel & Murgo, 2006). For example, an auditor may observe that hand hygiene is about to be missed and the patient potentially exposed to harm; this can result in the auditor having to decide whether to intervene to protect the patient but skew the data. Alternatively, does the auditor allow the HCW to continue uninterrupted and to 'miss' hand hygiene hence potentially placing the patient at risk (van de Mortel & Murgo, 2006)?

As has been noted, the ability to provide HCWs with feedback is seen as a major strength of direct observation. Azim et al. (2016) suggest that failing to give HCWs feedback about their noncompliance means that "human audit becomes (an) unethical methodology" (p. 775). However, there are those who argue that the provision of feedback during direct observational auditing can engender distrust between HCWs and those conducting the audits (Morgan et al., 2012). Azim et al. (2016) note that auditors will in fact predominately avoid interactions with those whom they are auditing. While a study by Boscart et al. (2012) indicated that nurses' willingness to offer feedback to their peers was negatively impacted by a desire to avoid intergroup conflict and to circumvent potential retaliation, with many wishing to "leave poor performers to their own devices" (p. 8). This

may suggest a certain reluctance by local auditors to provide the feedback, which is cited as being such a benefit of the direct observation method. In addition, McDonald et al. (2018) highlight the possibility that auditors may encounter rude or aggressive behaviour from those being audited, which would also have the potential to further lessen the likelihood of auditors providing feedback on noncompliant behaviours. Participants in the study by Mackrill et al. (2017) support this notion reflecting on how auditors are frequently "negatively perceived by healthcare professionals because of the policing aspect of their role" (p. 26). Furthermore, D. J. Gould et al. (2011) suggest that there "appear to be no published reports to testify the effectiveness of intervening to correct practice while audit is taking place" (p. 291). Larson and Kretzer (1995) argue that not only are intensive feedback interventions expensive and time consuming but are impractical in the longer term as well as of uncertain efficacy.

Direct observation has been described as having inherent flaws and epidemiological pitfalls. It is suggested that the data collected is inaccurate and misleading and that it contributes little to our understanding of hand hygiene compliance issues and behaviours (Cantrel, 2016; Fisher et al., 2013; Larson, 2013; McLaws & Kwok, 2018; Pong, Holliday, & Fernie, 2018). In May 2018, the UK House of Commons debated the use of direct observation as a data collection methodology, with participants describing the approach as outdated and no longer fit for purpose (Hansard, 2018). There followed an, at times, heated exchange on the Australasian Collage for Infection Prevention and Control (ACIPC) online forum questioning the accuracy, reliability, validity and practicability of direct observation as a continuing method by which to obtain hand hygiene compliance data in Australia (ACIPCLIST, 2018). While it is acknowledged that there are issues with the direct observation method of hand hygiene compliance measurement, the matter of whether they are enough to warrant the abandonment of the practice remains the subject of debate.

CURRENT COMPLIANCE AND DIRECT OBSERVATION

Australian national hand hygiene compliance rates have remained steadily above the 80% target (Figure 2) for several years with results for the three audit periods 2017, 2018, and 2019 (HHA, 2018).

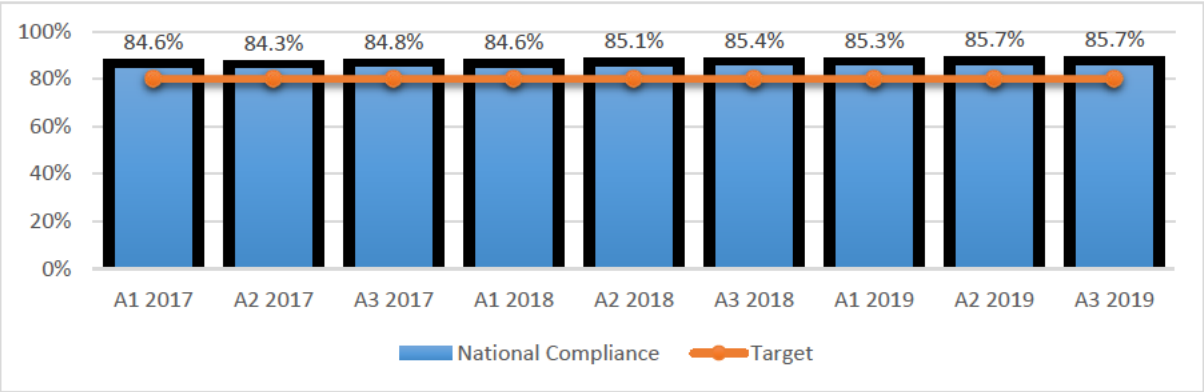


Figure 2. National Hand Hygiene Compliance - 2017-2019 (NHHI).

It is possible that many sites may have hit a natural ceiling on hand hygiene performance as measured using direct observation, having a steady rate despite multiple interventions to improve compliance. However, given the evidence to suggest that such results are an overestimation due to the collection methodology, it is proposed that this data may not be representative of the practice occurring the majority of the time.

The presumption of such satisfactorily high compliance may have the potential for adverse patient outcomes. The apparently high rates may induce complacency with regard to improvement activities and, as a consequence, inaction in terms of further efforts to improve hand hygiene behaviour. Respondents in the study by Mackrill et al. (2017) report how such apparently high compliance scores "make it hard to engage staff in improvement discussions as stakeholders believe they are doing well already and do not need further improvements" (p. 24). In turn, this situation would theoretically place patients at risk if the 'true' unbiased hand hygiene compliance rate is accepted as potentially being as low as one-third of that submitted (Srigley et al., 2014) and no action was being taken to address it. In addition, if infection rates fail to decrease in a setting with apparently high rates of hand hygiene compliance both clinicians and management may lose faith in the efficacy of this critical infection prevention intervention (Larson, 2013).

In response to the concerns about direct observation, it has been suggested that either changing the approach designed to increase compliance or changing the metric used to monitor compliance to collect less bias-impacted data should be considered. There is the potential that the latter approach would be likely to result in an apparent decline in compliance rates as a

consequence of the more accurate, less bias-impacted data collecting approach. However, it is contended that the benefits of recording true practice and the consequent ability to identify and correct noncompliant hand hygiene behaviour would outweigh these concerns. Furthermore, the recognition and remedy of compliance deficits would ultimately impact positively on patient safety by the potential for reduction of hand transmission of microorganisms.

Hence, there is a dichotomy. On one hand, there is a recommended (or in the Australian context, mandated) data collection method which, it cannot be denied, has many benefits. Yet direct observation is also acknowledged as having inherent flaws and disadvantages. This has led to calls to explore alternative compliance data gathering methodologies, most notably electronic measurement systems or devices. The utility of electronic monitoring systems as a solution to the problems of direct observation is explored in the literature review which forms Chapter 2 of this thesis.

THE RESEARCH PROBLEM

Direct human observational auditing of hand hygiene compliance is mandated practice in Australia and recommended internationally as the 'gold standard' method. However, the technique and the veracity of the resultant data is being increasingly questioned. Numerous electronic systems and methodologies have been proposed, developed and trialled as an answer to the problems of direct observation as are discussed in the Chapter 2 literature review. Yet at this point in time there does not appear to be a method able to collect information consistent with the current requirements to submit 5 Moments hand hygiene data to the NHHI under the framework originally outlined by HHA. This doctoral study explores the feasibility and utility of VMS. It includes the trial and evaluation of the video-based systems as a means of collecting hand hygiene Moments consistent with NHHI submission requirements but with greater efficiency and effectiveness as compared with the current gold standard method of direct observation as well as the investigation of the acceptability of the approach to HCWs and patients.

AIMS OF THE STUDY

The overall aim of this doctoral study was to explore the utility of VMS for contemporary hand hygiene auditing practice. For this study, utility was defined as coming to understand the methodological and technical specifications, whether video-based approaches could be effective, efficient and accurate, and whether it is acceptable to HCWs and patients. It was hypothesised that a video-based approach would demonstrate utility with respect to efficiency, accuracy and cost-effectiveness for measuring hand hygiene compliance according to the WHO 5 Moments for Hand

Hygiene. In this way the doctoral research study question of the utility of video-based monitoring approach was answered by the three interconnected, sequential studies. First, what technical and methodological specifications might be required for a video-based approach to contemporary hand hygiene auditing. Second, what is the effectiveness, efficiency and accuracy of VMS for contemporary hand hygiene auditing. Finally, what is the acceptability of video-based surveillance methods of hand hygiene auditing for HCWs and patients?

OUTLINE OF THE THESIS

This thesis comprises six chapters. Chapter 1 includes a background and context to the research problem, describes the stepwise approach to answering the research questions associated with the measurement of hand hygiene compliance, a statement of the research question and study aims and the outline of the chapters.

Chapter 2 is a review of the literature relating to the research problem and explores the current electronic hand hygiene compliance monitoring methodologies which are proposed as an alternative or an adjunct to the current gold standard method of direct observation. The aim was to identify the benefits and shortfalls of these modalities and inform the development of a video-based approach to hand hygiene auditing.

Chapter 3 provides the methodology used to gather the data required to answer research questions for the 3 studies presented in this thesis. It first reports on Study 1, which involves the thematic analysis of interviews with key informants involved in the hand hygiene auditing process, as well as discussions with technical and methodological experts. It describes how this data is then used, in conjunction with the information derived from the Chapter 2 literature review, to develop the proof-of-concept trial in simulation incorporating the use of VMS. For Study 2, it describes undertaking of the proof-of-concept trial simulation scenarios, which were recorded using various video-based approaches. Assessment as to the feasibly and time efficiency of auditing from the footage recorded using the developed technology was performed by a validated gold standard hand hygiene auditor. Finally, for Study 3, it describes the collection of data concerning the acceptability of the use of VMS for hand hygiene auditing to HCWs and patients via the thematic and content analysis of group interviews conducted with the Study 2 HCW participants, as well as descriptive analysis of data from online surveys conducted with HCWs and patients/consumers and the thematic and content analysis of Interviews with volunteer key informant respondents from the online survey.

Chapter 4 presents the results of the 3 studies. For Study 1 which, it combines information from the literature review and discussions with technical and methodological experts and allowed for the methodological and technical specifications of the overall approach to be developed. For Study 2, it establishes the technical ability to audit according to the 5 Moments framework from the footage recorded with a VMS, including the quantification of the time efficiency of the approach. Further, the approach was able to be modified as a result of the analysis. Study 3 is then reported, being the exploration of HCW and patient concerns and attitudes relating to the experience with or concept of the developed video-based electronic surveillance method of hand hygiene auditing.

Chapter 5 presents a discussion of the results in the context of the current literature. It includes an outline of the technical and methodological specifications for a VMS for use in the auditing of hand hygiene compliance according to the WHO 5 Moments. A discussion of the feasibility and time efficiency of the approach as well as an exploration of HCW and patient attitudes to and acceptability of the method is included. The thesis concludes with Chapter 6, which recounts the aim of the study and critically evaluates the findings with recommendations.

CHAPTER 2: LITERATURE REVIEW

INTRODUCTION

This chapter presents the results of the literature review which informed and guided the design and conduct of the study. The aim of this study was to explore the utility of video-based monitoring system for auditing hand hygiene compliance. The review of the literature relevant to this study of hand hygiene compliance auditing was performed continuously during candidature as it related to the 3 interrelated studies.

The search included research and professional literature relevant to the research question within standard electronic databases including MEDLINE™, CINAHL™, ERIC™, PsychINFO™, Cochrane™, ProQuest™, ScienceDirect™, ProQuest Dissertations) and the World Wide Web. Key Medical Subject Heading (MeSH) terms used in the search included hygiene, hand hygiene, hand sanitization, hand disinfection, cross infection, infection control, electronic, digital technology, video, video recording and surveillance. References from all relevant articles were retrieved and examined for relevance. All searches were restricted to citations published in English, and a date restriction of publication up until September 2022 was applied. The analysis of the literature is arranged thematically and into two areas, which are elaborated below. The review begins by exploring and examining the utility of electronic monitoring systems more generally, followed by a narrowing of focus to investigate the possibilities for video-based approaches in relation to the research question.

ELECTRONIC MONITORING SYSTEM SOLUTIONS FOR PROBLEMS ASSOCIATED WITH DIRECT OBSERVATION

The question as to whether electronic monitoring systems present the solution to the problems inherent in the direct observational methodology has been the subject of considerable debate in recent literature. Some authors see the transition away from human auditing as an inevitable fait accompli. For example, Azim and McLaws (2014) contended that direct observation has utility “until auditing is universally automated” (p. 4) suggesting that it is merely a matter of time, and perhaps further technological innovation, until it is superseded by automated methods. Congruently, McLaws and Kwok (2018) contend that automation monitoring provides “superior reliability and validity” (p. 4) as compared to human auditing. Kwok et al. (2016) similarly asserts that, “automation is superior to human auditors for data accuracy” (p. 1479) and are hence in agreement with Alper (2015) in that the progression to electronic data collection methods is not

only inevitable but desirable. Marra and Edmond (2014) note, this transition will “obviate the need for direct observation” (p. 29).

However, arguments that direct observation should be totally abandoned in favour of the emerging technologies are certainly not universal. Many authors do not see it as an all or nothing position. For example, Helder, van Goudoever, Hop, Brug, and Kornelisse (2012) promote combining data collected by electronic and direct observational methods in order to achieve a more comprehensive overview of hand hygiene practice. Numerous other authors agree with the contention that data collected via electronic compliance monitoring systems can variously enhance, complement, supplement or provide additional information to that collected by direct observation (Conway, 2016; D. J. Gould et al., 2007; Pincock et al., 2012; Storey et al., 2014). A review by the WHO in 2013 concluded that while electronic methods were promising and had the potential to be “part of the future approach to hand hygiene monitoring” (p. 3) there would still be an ongoing requirement for direct observational auditing. Other authors are less positive about the future and potential of electronic systems with Pires and Pittet (2017) suggesting that even with rapid technological advances in recent years, the technology “still has not revolutionised hand hygiene” (p. 464). While a systematic review by Srigley et al. (2015) concluded that there was insufficient evidence to recommend electronic monitoring systems as a compliance monitoring method. Another factor contributing to this debate in the literature is the variability of definitions, terms and language used to describe the approach and precisely what is meant by the concept of electronic monitoring for hand hygiene auditing.

ELECTRONIC MONITORING SYSTEMS AND THE RESEARCH PROBLEM

The aim of this study was to explore the utility of video-based monitoring as a hand hygiene compliance data collection method consistent with both the WHO 5 Moments for Hand Hygiene and the previously stated NHHI criteria. It has been established that the gold standard, and indeed mandated, method has merits. Yet this data collection methodology is also, undeniably, problematic. Similarly, electronic monitoring systems, which are frequently proposed as the solution to the problems identified with regard to direct observation, have both pros and cons. It is important therefore to explore existing technologies and the methods by which they were trialled and utilised for potential applicability or adaption to the current research question.

ELECTRONIC MONITORING SYSTEMS – DEFINITIONS AND SYSTEM PARAMETERS

The literature on electronic hand hygiene monitoring technology demonstrates considerable variation in the language and terms used. Various attempts have been made to characterise or

categorise the various ‘electronic’, ‘computerised’, ‘automated’ or ‘video-based’ surveillance methods for monitoring HCW compliance with hand hygiene. The term electronic monitoring system, frequently referred to as electronic monitoring systems or EMS in the literature seems common, with the appellation VMS or Video Monitoring System for camera-based systems. However, there continues to be a level of disagreement in the literature as to how such technologies should be not only named, but classified or grouped. Electronic monitoring systems differ considerably in both their scope and purpose. Several categories have been suggested according to system intent or function. However, the examination of the literature makes it clear that none of these categories is exclusive and that there is significant cross over between taxonomies.

Hand Hygiene Product Usage or Event Counting Systems

The 2009 WHO Guidelines on hand hygiene in healthcare recommend that the measurement of hand hygiene product consumption, either ABHR or soap, be used as a secondary or additional metric for monitoring hand hygiene compliance behaviours. This method may be as simple as tracking the volume of product used over time, for example millilitres per day, week or month and then establishing upward or downward trends. The assumption being that increased consumption of product correlates with increased compliance. Another option involves calculating hand hygiene events or occurrences by dividing the volume used by the dispensing aliquot to estimate the number of times that hand hygiene was performed for a given time period (WHO, 2009).

A more sophisticated version of the product consumption method is perhaps the simplest of the electronics monitoring systems described in the literature. These so-called dispenser activation or count based systems, record a hand hygiene event as having occurred each time a dispenser is pressed or activated and vary considerably in terms of scope and functionality. Kinsella, Thomas, and Taylor (2007), for example, report a simple dispenser-based counter system requiring manual download of data. This system was able to track hand hygiene event rates and reported that there was an increase in hand hygiene performance linked to periods of greater patient acuity and workload. Koff et al. (2009) and Koff, Corwin, Beach, Surgenor, and Loftus (2011) report the use of portable dispenser counter devices, again requiring manual download of data. These devices were able to count the number of hand hygiene events that an individual performed. In the 2009 study the device users (anesthetises working in theatre) were also prompted to perform hand hygiene every 6 minutes, and this was associated with a 2.5-fold increase in the hand hygiene event rate as well as a reduction in both intravenous line contamination and HAIs. The 2011 study described the use of the same device to track the frequency of hand hygiene performed by ICU staff following a

compliance raising intervention. The authors contend that the device recorded an increase in hand hygiene event rate following the intervention and further that this was associated with a reduction in ventilator-acquired pneumonia in the study population.

More sophisticated systems have subsequently been developed. Scheithauer et al. (2018) described a Wi-Fi enabled system which measured, automatically downloaded and reported overall hand hygiene events in an ICU over an 8-month period and was able to track fluctuations in performance. Both Muller, Levchenko, Ing, Pong, and Fernie (2014) and Albright et al. (2018) described variations of Wi-Fi enabled dispenser activation systems, which included the use of personal identification tags. While most count-based systems do not provide this level of detail, the data provided by these systems was able to differentiate the hand hygiene events according to HCW designation as well as by time, date and dispenser location.

A further variation on the count-based systems are those that use the dispenser activation count figure to calculate a form of compliance percentage. Vaidotas et al. (2015) utilised entry as detected by electronic surveillance as the denominator and the hand hygiene event rate as counted by dispenser activation as the numerator. The technology was able to calculate a compliance rate of between 7.1% and 17% for hand hygiene upon entering the study hospital. Sahud et al. (2010) described a similar system where compliance rate was calculated by dividing frequency of dispenser activation by that of room entry. The addition to this system was that data was able to be attributed to individual tags carried by HCWs meaning that a weekly compliance figure was provided to each individual. Arai et al. (2016) used dispenser activation count at the numerator and patient visits/appointments as the denominator in their study conducted in an Outpatient's clinic. The somewhat concerning expectation was that there would only be a single episode of hand hygiene per patient. The authors report that they were able to use the system to track an increase in 'compliance' from 10.7% to 18.2% in response to a program of regular feedback of results.

Perhaps the most complex variation of an event counting system are those which use a calculated denominator based on extensive direct observational auditing. Steed et al. (2011) describe a system which utilises dispenser activation count as the numerator. The denominator was a daily hand hygiene opportunity figure that was derived from over 430 hours of direct observational auditing. This figure could then be adjusted to reflect bed occupancy, patient acuity and staffing levels. The system was also able to provide a live compliance rate. The daily hand hygiene opportunity figure developed by Steed et al. (2011) was further adapted and utilized by Bouk, Mutterer, Schore, and Alper (2015) and Conway et al. (2014) to calculate compliance in similar dispenser counting systems they trialled. Azim et al. (2016) subsequently replicated the work of

Steed et al. (2011) in the Australian setting. Direct observational audits were conducted 24 hours per day over a 7-day period on 2 wards by a team of 60 trained auditors. Four auditors were auditing at any given time to ensure that the majority, if not all, hand hygiene opportunities were recorded. The result was a baseline daily hand hygiene opportunity number which could, as in the study by Steed et al. (2011), be adjusted according to census data to derive a daily denominator from which to calculate compliance percentage.

Tag-Based, Zone and Locational Systems

So called tag or badge-based locational systems provide a higher level of detail about HCW hand hygiene behaviour than dispenser activation, count-based approaches and are, in general, more complex technologies. This form of electronic monitoring system also varies considerably in terms of capacity, scope and function with an increasing number of different systems being trialled, reported and made commercially available. These systems are also known as real-time location systems, entry/exit systems, automated systems or badge-based systems (Boyce, 2017a; Dufour et al., 2017; McLaws & Kwok, 2018; Ward et al., 2014). These monitoring systems range from relatively simple to elaborate and complex. What they have in common is the delineation of some form of patient zone and linkage of entry to or exit from this space to hand hygiene performance via product dispenser activation (Boyce, 2017a; Ellison et al., 2015; Levchenko, Boscart, & Fernie, 2013; Srigley et al., 2014; Ward et al., 2014). Compliance or noncompliance is in turn dependent upon the combination of movement into or out of the designated zone with the use of a ABHR dispenser. HCWs are required to wear or carry a device which records both their entry and/or exit as well as associated dispenser activation which is, in turn, seen as a hand hygiene event. Staff may be tracked or monitored to the level of HCW designation or even the specific individual (Al Salman, Hani, de Marcellis-Warin, & Isa, 2015; Boyce, 2017a; Fisher et al., 2013).

One of the earliest of this form of systems was trialled by Swoboda, Earsing, Strauss, Lane, and Lipsett (2004) in Baltimore in 2000. This system used “electronic beam breakers or motion detectors” (p. 359) to delineate zones. It also incorporated the use of electronically monitored sinks, dispensers and toilets to define compliance as linked to the entry and exit from the aforementioned zones. The primary aim of this system was described as being compliance improvement and the subsequent reduction in HAIs. Despite this focus, monitoring of hand hygiene behaviour was clearly within the capacity of the system. The authors report hand hygiene compliance rates at baseline of 19.1% and a subsequent improvement to a peak of 27.3%. This was associated with a multi-resistant organism (MRO) colonisation rate reduction from 19% to 9%.

More sophisticated and recent systems utilise zones around the patient bed area delineated by proximity beacons, often employing infrared or ultrasound technology. These systems typically require HCWs to wear a badge or carry a device which are detected via Wi-Fi by a series of beacons or electronic controllers which in turn define the patient zone (Al Salman et al., 2015; Boscart et al., 2010; Pong et al., 2018). Boscart et al. (2010), for example, described the use of a badge-based system which detected HCW entry to or exit from a designated zone and provides a prompt signal until hand hygiene is performed. Again, while this technology measures compliance as defined by the system, the primary focus of the technology and the associated study appears to be the efficacy of the prompting function in terms of compliance improvement.

Similarly, there are those systems which involve the use tags or badges that activate or trigger upon entry to or exit from designated zone, but which incorporate a timing parameter in the definition of compliance. A hand hygiene Moment or event will only be recorded as compliant if the linked product dispenser is activated within a pre-determined time before or after the entry or exit trigger (Swoboda, Earsing, Strauss, Lane, & Lipsett, 2007; Ward et al., 2014). Cheng et al. (2011) describes the use of such a system with proximity zones and HCW badges. This electronic monitoring system incorporated as algorithm based on the duration the HCW spent within the defined zone to predict the likelihood of patient contact and hence the requirement to perform hand hygiene. This translated to the requirement for hand hygiene to be performed within 90 seconds of entry or exit for the event to be deemed compliant. The system had the capacity to monitor hand hygiene behaviour to the level of the individual badge, although the use of so called “generic HCW badges”, which were shared amongst those of the same HCW designation, meant that specific individuals were not identified. The primary use of the electronic monitoring technology as described in this study was for compliance monitoring, as well as the comparison of hand hygiene compliance rates collected via the system and using direct observation.

The system described by Fisher et al. (2013) also incorporated a timing requirement. In this instance, HCWs were required to activate dispensers within 6 seconds of entry to and within 1 minute of exit from the defined zone. These values were chosen arbitrarily “based on pre study observations” (p. 920). The system incorporated a reminder “beep” function, as well as weekly compliance reports. However, over the 10-week trial there was only a modest increase in hand hygiene compliance from a baseline of 28% to 33% on entry and from 24% to 32% upon exit. The electronic monitoring system was able to track changes in hand hygiene compliance secondary to the intervention, which was the use of the electronic monitoring system itself via the “reminder” or prompting functionality. Al Salman et al. (2015) used a similar system with proximity zones, tags and linked dispensers, as well as associated reminder prompts. The system was trialled for 28 days and

was credited with recording 15,769 room entries or exits, as well as being associated with an improvement in compliance from 60% to 82%.

Some devices simply record the fact of an entry or an exit while others have the capacity for real-time locational tracking of the wearer or carrier of the device (Cheng et al., 2011; Filho et al., 2014; Levchenko et al., 2013; Monsalve et al., 2014; Srigley et al., 2013). As noted, some systems will track individual HCWs, while others will produce only broad information such as HCW designation or not provide any additional level of detail at all. Some technologies may also include a reminding or prompting feedback system with a form of notification as has been described above. This may include a flashing light, audible tone and/or the vibration of a carried device that activates if hand hygiene is not detected with in a prescribed time period following entry or exit (Edmisten et al., 2017; Edmond et al., 2010; Filho et al., 2014; Levchenko et al., 2013; Swoboda et al., 2007). The provision of continuous, real-time or rapid feedback of compliance via a screen or display board, emails to managers or even directly to individual HCWs may also be a feature of such systems (Boscart et al., 2010; Bouk et al., 2015; Conway, 2016; Ellison et al., 2015; McGurkin & Govednik, 2015)

One quite unusual, and perhaps unique, system is that described by Dufour et al. (2017). Rather than proximity beacons, this system utilised sensors embedded in doorways and in the floor around patient beds. Sensors were implanted in HCWs shoes and the requirement for hand hygiene was defined as being at point of entry to the patient room and then again into the zone around the bed area. Compliance was measured via activation of linked dispensers at the doorway and the bedside in response to entry into each of the zones.

In addition to the classifications described above there has been a small number of reports of systems incorporating alcohol sensing technology. Edmond et al. (2010) described such a system where, upon room entry, triggered a requirement to use ABHR and which was further required to be ‘proven’ by the scanning of the HCWs hands with an alcohol detecting ‘badge’. Failure to comply resulted in audible and visible alerts which would hence encourage compliance.

PURPOSE AND INTENT OF ELECTRONIC MONITORING SYSTEMS

Having had a brief overview of electronic monitoring system parameters and functionality, it is important to also examine the purpose and intent of these systems. It could readily be argued that the commonly used descriptor ‘Electronic Monitoring Systems’ would inherently suggest that the primary function of these technologies is the monitoring, measuring and/or recording of behaviours relating to hand hygiene compliance practice. Certainly, as will be discussed, electronic monitoring

systems have significant capacity to monitor and record hand hygiene behaviours, however it is often unclear in the reports from trials, studies or systematic reviews whether this is the intended primary aim or function of the technology being investigated. McGurkin and Govednik (2015) use the term “electronic interventions” (p. 351), the name at least suggesting an intent to elicit some form of change. Apart from electronic data management systems, such as data collection ‘apps’ or the use of collection devices such as tablets, the authors described systems in terms of “behaviour monitoring systems” or “technique improvement systems” (p. 351). However according to their definitions, the latter refers to the qualitative aspects of hand hygiene as distinct from the measurement of compliance behaviours. The former incorporates behaviour change aspects secondary to the provision of feedback. Ellison et al. (2015) refers to the capacity of electronic monitoring systems to “monitor and promote” (p. 1) hand hygiene behaviour, while Armellino et al. (2012) report how the system they trialled was successfully able to monitor and reinforce hand hygiene behaviour. Similarly, the 2013 WHO report, while acknowledging the capacity of electronic monitoring systems to record compliance, notes how such systems have also been “studied as an intervention to improve hand hygiene with successful results” (p. 3).

Other authors appear to have moved away from the monitoring aspect of the technology, apparently focusing on the primary function of these systems as being “improving and sustaining compliance“ (Srigley et al., 2013, p. 5). Or as Kwok et al. (2016) argues, electronic monitoring systems have been found to be “valid and useful in effecting change” (p. 1476).

It is pertinent to recall how Conway (2016) describes the primary function of hand hygiene compliance monitoring as being to “gather information and give it back to HCP so that they can use it to change their practice” (p. 7). It could clearly be argued that this sentiment is applicable and relevant whether the data was collected by human or automated means. However, with some technologies the situation is somewhat unclear, and clarification is needed as to whether the intent of the system is to collect data which the individual can use in order to change their practice or whether the aim to create change directly as a consequence of the application of the technology itself.

ADVANTAGES OF ELECTRONIC MONITORING SYSTEMS

Gathering Big Data

Advocates of electronic monitoring systems highlight a number of advantages of such approaches to hand hygiene compliance auditing over the current method of direct observation. First, and foremost, electronic monitoring systems enables the collection of large amounts of data,

which has been regarded by some, like Fisher et al. (2013), as the major benefit of this technology. Count-based systems in particular can operate unobtrusively, 24 hours per day/ 7 days per week with little or no input from or burden to HCWs (Conway et al., 2014; D. J. Gould et al., 2017; Haas & Larson, 2007; Marra & Edmond, 2014). In addition, the majority of systems are designed to operate continuously over an extended period of weeks or months (Kwok et al., 2016; Srigley et al., 2013). The ability to monitor practice and collect data over all shifts and days of the week is seen as a significant benefit as a more complete picture of hand hygiene practice can be captured (Boyce, 2017a; Storey et al., 2014). Such systems are therefore able to offer a level of "constant oversite that is impossible to achieve with direct observation" (Ellingson et al., 2011, p. 1092), particularly at times when direct observation is considered to be neither practical nor objective (Ellingson et al., 2011; Storey et al., 2014). For example, electronic monitoring systems can collect data overnight and during weekends. Direct observation auditing rarely occurs at these times due to decreased data collection efficiency secondary to low staff numbers. In addition, there are the difficulties associated with maintaining a discrete auditing presence at these times and hence potentially increasing the impact of the Hawthorne Effect (Azim et al., 2016; Ellison et al., 2015; Storey et al., 2014).

As noted, the data may also be collected over a prolonged period, weeks, months or even years in what Armellino et al. (2012) describes as an "effortless" manner. The continuous and long-term nature of the data collection means that large amounts of information about hand hygiene practice can be recorded. Variously described as "comprehensive", "huge" and "massive" in volume, the information which electronic monitoring systems can collect result in the recording of significantly higher numbers of hand hygiene events than would be practically possible with direct observational auditing (Conway et al., 2014; Edmisten et al., 2017; Venkatesh et al., 2008). For example, Scheithauer et al. (2018) reports that their count-based system was able to collect 88,756 Moments from a 14 bed ICU over a 7.5 month period. Conway et al. (2014) describes the collection of 1,778,852 hand hygiene events over a 15 month period. Boyce (2017a) describes the data collection capacity of such systems as being "orders of magnitude greater" (p. 530) as compared to that of direct observation. Azim et al. (2016) reports a system which was able to demonstrate the collection of more than 4 times the number of Moments in a single day than typically collected in an entire NHHI audit period and the automated system described by McLaws and Kwok (2018) recorded an estimated 578 times more data over an audit period as compared to what was usually collected by human auditors over the same interval.

These large numbers are seen as advantageous in that they provide a "more comprehensive dataset" (Sahud et al., 2010, p. 638). Not only is this data considered more robust and statistically significant than the small, so called 'snap shot' samples typical of direct observational audits, but

electronic methodologies are considered to have “tremendous potential to overcome statistical barriers to valid hand hygiene adherence auditing” (Ellingson et al., 2011, p. 1094).

The capacity to generate such datasets is also seen as advantageous with the large numbers of hand hygiene events that these systems can record meaning that the technology can more sensitively detect changing trends in hand hygiene behaviour as compared to the snap shot data provided by comparatively small, episodic direct observational audits (Boyce, 2008; Marra & Edmond, 2014; Sodre da Costa et al., 2013). Azim et al. (2016) notes how the count-based system utilized in their study was able to provide “reliable and immediate registration of the success of ward-based education and intervention” (p. 776). Additionally, D. J. Gould et al. (2011) cites the benefits of such data as a “general screening tool to indicate clinical areas where compliance appears to be problematic ” (p. 291) thus flagging an area for follow up, review or intervention. Although this ability to collect large amounts of data is lauded by many as a major advantage of electronic monitoring systems , Pires and Pittet (2017) do sound a note of caution, warning “the risk is to accumulate large amounts of data of questionable relevance” (p. 465) as will be further explored.

Another benefit, which relates to systems which include an activation tag, is the ability to record detailed information about who is or is not performing hand hygiene. As has been noted, some systems use a generic badge shared among members of the same craft group (Al Salman et al., 2015; Cheng et al., 2011) while others track individual HCWs allowing for personalised feedback of compliance data (Dufour et al., 2017; Edmisten et al., 2017). Information about which HCWs or HCW groups are or are not performing hand hygiene can be useful in developing targeted remediation strategies (Boyce, 2017a).

Reducing Human Resources for Data Collection

Advocates of electronic monitoring systems also note the benefits of these systems in terms of the reduction of human resources required for data collection. As has been noted, most electronic monitoring systems will operate 24 hours/day, 7 days/week with little or no human intervention. As a result, they will achieve the recording of numbers of hand hygiene events which would be impossible to facilitate with direct observation in terms of both personnel time and consequent financial resources (Cantrel, 2016; Diller et al., 2014; Edmisten et al., 2017; Filho et al., 2014; WHO, 2013). Indeed, Cheng et al. (2011) saw their system as the solution to their “limitation in manpower” (p. 2) with which to conduct human auditing. Hence, proponents also argue the benefits of such systems on the grounds of savings in terms of both costs and human resources (Scheithauer, Haefner, & Schwanz, 2009; Storey et al., 2014; WHO, 2013).

Kwok et al. (2016) also cites the benefit of a consequent reduction in auditor attrition. This is due to a reduction of the local auditors' workloads and the time conflicts between their clinical and auditing roles. Thus, there is also a saving of time and resources that would otherwise be required for the training and support programs for maintaining and replacing ward-based or peer auditors.

Reducing Bias in Data Collection

As was noted in Chapter 1, one reason that direct observation is considered a flawed metric is due to the various biases inherent in its methodology, and hence the lack of bias attributed to electronic monitoring systems data collection is seen as another major advantage of such approaches. Indeed, the words 'unbiased' and 'objective' are both frequently associated with reports and descriptions of electronic monitoring systems in the literature (Haessler, 2014; Sahud, Bhanot, Narasimhan, & Malka, 2012; Srigley et al., 2014) In general, data collection via electronic monitoring systems are seen as being either free from, or far less subject to, the various biases and accuracy issues associated with direct observation (Helder et al., 2012; Masroor et al., 2017). Advocates of electronic monitoring systems promote such systems on the grounds that they collect data that is more valid and reliable than that obtained by direct observation (Alper, 2015; Diller et al., 2014). The automated and continuous recording of hand hygiene behaviours mean that the majority, if not all, of hand hygiene events are recorded without conscious or unconscious selection of good or bad practice, thereby eliminating the potential for selection bias (Armellino et al., 2012; Srigley et al., 2015). In contrast, direct human audits tend to occur intermittently, mainly during daylight hours and on weekdays and have been estimated to capture less than 3% of Moments actually occurring (Boyce, 2011). Cantrel (2016) argues that electronic monitoring systems allow variables and inconsistencies typical to data collected by direct observation to be eliminated. Kwok et al. (2016) endorses the use of electronic monitoring systems as such a methodology will avoid the "serious associated epidemiologic flaws" (p. 1479) linked to human auditing.

Electronic Monitoring Systems and the Hawthorne Effect

The Hawthorne Effect is regarded as a significant disadvantage of data collection via direct observation. Some who advocate the adoption of electronic monitoring systems do so on the basis that these technologies are capable of collecting data that are not artificially inflated by the physical presence of an observer in the clinical space (Diller et al., 2014; Dufour et al., 2017). This is because many electronic systems have the capacity to collect data in a continuous and less obtrusive manner compared to a human auditor standing nearby with a clipboard or data collection device. Venkatesh et al. (2008) supported the notion of the elimination of the Hawthorne Effect as a result of the use of electronic monitoring of hand hygiene compliance. The authors undertook a study utilizing an

electronic monitoring system to improve compliance, but which also involved a comparison between automated and direct observational data collection. In addition to improved hand hygiene compliance and a reduction in horizontal vancomycin-resistant *Enterococcus* transmission, they concluded that such systems were able to record hand hygiene behaviours "without observational bias" (p. 204).

Boyce (2017a) notes that electronic monitoring systems provide data that is "not effected by the type of Hawthorne Effect that occurs in the presence of a human auditor" (p. 531). The use of the word 'type' is interesting as it would suggest that these systems do in fact exert some form of influence upon HCW behaviour, but that is not the same as that resulting from direct observation. Filho et al. (2014) use similar language in reporting their study. The authors asserted that the electronic monitoring system used "mitigates the Hawthorne Effect" (p. 1191) following their investigation into the accuracy of a badge-based system. The primary focus of the investigation was to compare the accuracy of their system as compared to concurrent direct observation. The results demonstrated that the electronic monitoring system could detect 92% of the hand hygiene events that the human auditors were able to capture. However, an interesting additional finding, as was noted in Chapter 1, was that while the system operated continuously, a statistically significant spike in hand hygiene event rate was observed in the one-hour periods in which the human auditor was physically present, compared to the average overall rate and in the time immediately preceding their arrival. Similarly, Srigley et al. (2014) found that during a period of continuous hand hygiene event recording using a dispenser activation electronic monitoring systems, statistically significant increases in performance (approximately threefold) were documented whenever a human auditor was present and collecting data via direct observation. Cheng et al. (2011) reported comparable findings from their study involving periods of parallel direct observational auditing and the use of an electronic monitoring system as part of a 3-month trial of the technology. During the 20-minute periods that the human auditor was present it was noted that the hand hygiene rate was 2.8 times higher. Other authors are similarly cautious, suggesting that the use of an electronic monitoring system for data collection, is effective in "minimizing the Hawthorne Effect" (Dufour et al., 2017, p. 351), that the technology "reduces these biases" (Conway, 2016, p. 7) or that such systems may "overcome the Hawthorne and avoidance effects" (D. J. Gould et al., 2017, p. 169). While in the WHO 2013 report, the authors note that although electronic monitoring systems may not offer a total solution to the problems associated with direct observation, they may have the possibility of a "lower Hawthorne Effect" (p. 2). While it does not rule out the possibility that electronic monitoring systems can alter hand hygiene behaviour via some form of the Hawthorne Effect, the notion that such impacts are reduced with the use of these technologies is heavily supported.

There is, however, some debate as to whether more overt electronic monitoring systems do in fact intentionally harness the Hawthorne Effect (Diller et al., 2014; Geilleit et al., 2018; Marra et al., 2010). It would be logical to suggest that a discreet monitoring system such as those which count hand hygiene events via dispenser activation, would be less likely to induce behaviour change via the Hawthorne Effect than a more overt and obvious tag-based system, particularly one with prompting or reminder functionality. Not all authors endorse this view however. Venkatesh et al. (2008), for example, reported that the improvements in compliance noted in their study may have been because staff were or became aware of the monitoring function of their trialled system. This electronic monitoring system, which was able to link room entry with noncompliance as defined by the system and to respond with visual and auditory prompts, was associated with a statistically significant increase in hand hygiene compliance and was clearly designed to elicit a behaviour change. The monitoring function of the technology was not explicitly revealed to the clinical staff although the author's conjecture that this information may have become known and hence note that the installation of the dispensers "may also create a potential for the Hawthorne Effect" (p. 204). Thus, they argue, it may not be possible to attribute improved hand hygiene rates solely to the prompting function of the technology.

It must be recalled, as has been discussed, that the purpose of many of these systems is in fact, to induce behaviour change, or as Al Salman et al. (2015) noted regarding the system they trialled "instil learning patterns" (p. 123). It could clearly be argued that part of this behaviour change may relate to impact of the Hawthorne Effect due to the overt continuous monitoring that badge-based locational systems incorporate. Srigley et al. (2015), for example, considers this a major advantage of the approach and describes the continuous monitoring provided by this technology as creating an "enhanced Hawthorne Effect" (p. 52). Kohli et al. (2009) concurred that the Hawthorne Effect should be "harnessed as a tool to improve hand hygiene compliance" (p. 222). Pittet (2002) is also a strong advocate of harnessing the Hawthorne Effect to positively impact hand hygiene behaviour, stating:

> *"My personal opinion is that obtaining a sustained and never-ending Hawthorne Effect associated with improved hand hygiene and decreased infection and cross transmission rates should be the dream of every hospital epidemiologist. Let's find a cost-effective way to induce it!" (p. 119)*

It could be argued that the degree to which, or indeed whether, an electronic monitoring system impacts on HCW behaviour may depend on the design, functionality and intent of the system itself. For those with the primary aim of long-term, continuous and discreet data collection without any

immediate interaction with HCWs, it is unlikely that the impact on behaviour and hence compliance rate, via the Hawthorne Effect, would be significant. On the other hand, systems which incorporate more overt surveillance that, for example, require HCWs to wear or carry a device, to change their practice or workflows or to be subject to on-the-spot prompts, reminders or feedback are bound, if not purposefully intended, to promote behaviour change. The functionality of audible or visual prompts and reminders or the requirement to perform certain behaviours such as the scanning of hands to detect alcohol vapour as described by Edmond et al. (2010) would serve as a constant reminder that hand hygiene practice was being monitored. It is unclear, however, how much of the recorded behaviour changes can be attributed to the Hawthorne Effect per see and how much is as a result of the enhanced reminders and feedback that these technologies provide. It is perhaps pertinent to consider the findings of a study by Cheng et al. (2011). The authors' note that during their trial of a badge-based electronic monitoring system, HCWs whose individual compliance was able to be tracked and recorded showed much higher compliance as compared to those who utilised a generic badge capable of identifying only HCW designation and who therefore could not be personally identified. Thus, suggesting that those subject to more overt observational methods, be they human or electronic, will have an increased likelihood of behaviour change and that potentially this would be as a consequence of leveraging by the Hawthorne Effect. Similarly, Storey et al. (2014) describe the use of a badge-based system incorporating a light, which was visible to the wearer's colleagues as well as patients, which activated when noncompliance with hand hygiene was detected. Use of this system was associated with improved compliance and it could be argued that this may have in part been due to the Hawthorne Effect. Staff may have felt that their practice was being observed by others through the medium of the visible indicator of hand hygiene behaviour and altered practice accordingly.

Providing Feedback and Changing Behaviour

The aim of some electronic monitoring systems is not just to monitor compliance with hand hygiene, but also to induce behavioural changes to improve it. A proportion of the improved compliance resulting from automated systems may be attributed to the impact of the Hawthorne Effect and the continuous oversight that such systems provide. Another mechanism for improved compliance is via the prompts, reminders or the provision of feedback that is a feature of many electronic monitoring systems. Although the provision of feedback by auditors is claimed as one of the major advantages of direct observations, it is also suggested that this practice occurs less frequently than is desirable. Providing feedback is seen as an important strategy by which to achieve change (Kwok et al., 2016) and further, electronic monitoring systems are seen as having great potential to provide these continuous reminders ideal for "promoting and maintaining behaviour

change" (Pires & Pittet, 2017, p. 465). As Azim et al. (2016) contended, feedback to enable positive behaviour change is the purpose "for which surveillance is designed" (p. 776). Various prompting, reminder and feedback functions are reported in the literature and at times it can be difficult to distinguish whether a system response functions as a prompt, as a form of immediate feedback or as a combination of both. Some systems, for example, will indicate compliance or noncompliance via audible, visual or tactile cues such as beeps, badge vibrations or warning lights above beds or on badges themselves (Boscart et al., 2012; Edmisten et al., 2017; Levchenko, Boscart, & Fernie, 2011; Pong et al., 2018). Other systems even provide a verbal reminder to staff to "please wash their hands" (Swoboda et al., 2007, p. 471). Many badge-based systems provide immediate feedback of compliance, as well as a prompt if a hand hygiene event is not recorded when it should have occurred in relation to the system defined temporal and/or proximity indicator. This in turn has been shown to further drive compliance (Fisher et al., 2013; Srigley et al., 2013).

Electronic monitoring systems may also provide feedback in the form of results or compliance data. This may be displayed in a public "scorecard" manner on monitors, screens or display boards in the clinical space. Alternatively, it may be sent to managers for distribution to teams or individuals or may even be sent to individuals personally depending on system parameters (Arai et al., 2016; Armellino et al., 2012; Ellison et al., 2015). It is worth noting that the benefits of the prompting and feedback functions of electronic monitoring systems goes beyond those induced by the mere presence of the technology in the clinical space and the previously noted Hawthorne Effect that it may imbue. This was recognised by Armellino et al. (2012) in a study which found that although HCWs were aware of the presence of a system monitoring their practice in the initial phases of the trial, it was not until when the feedback process commenced that dramatic and statistically significant increases in compliance were noted. These results not only support the contention that discreet monitoring systems have no or only minimal impacts on behaviour via the Hawthorne Effect, but also highlight the important role that feedback plays in terms of a positive impacts upon compliance. In a similar vein, a study by Ellison et al. (2015) demonstrated a baseline hand hygiene event rate to entry/exit ratio of 26.1% recorded by a known but passive electronic monitoring system. This increased to 33.7% when a reminder/prompt chime was added and further increased to 36.6% when the chime was coupled with a numerical feedback display on a public screen. The ratio decreased to 32% when the chime was discontinued, and the screen remained and further decreased to 30% 4 weeks after the system resumed its passive function and all supportive interventions were withdrawn. This would again support the potential benefits of both the prompting and feedback functionality of electronic monitoring systems in improving the frequency of hand hygiene events. Srigley et al. (2015) cautiously concurred, stating that "systems which

combine both individual feedback and real-time reminders would seem, a priori, to have the greatest potential to impact compliance" (p. 58).

Not only is the provision of feedback believed to be an important attribute of an electronic monitoring system, but even more so the fact that many systems boast the capacity to provide this information in real-time or near real-time (Armellino et al., 2012; Diller et al., 2014; Dufour et al., 2017). An important attribute of effective feedback is that it is delivered in a timely manner, although the manner in which the feedback is delivered may vary considerably depending on the individual system.

As has been noted, some EM electronic monitoring systems provide feedback which is also intended as a prompt for action. For example, Storey et al. (2014) described a system with immediate feedback involving the wearing of a badge with indicator lights which flashed green when hand hygiene should be performed and then indicated red if it was not attended. The authors reported a significant increase in the hand hygiene event rate (21.6% to 66.5%) when the system was implemented, although it must be noted that the long-term efficacy of the technology was not tested as the total study duration was approximately 10 weeks. In addition to immediate feedback via badges or alarms, real-time or near real-time feedback may take the form of a live, or regularly updated display screen which gives the current hand hygiene rate as defined by the system in use (Ellison et al., 2015; Sahud et al., 2012). Alternatively, the system may provide feedback via the generation of electronic reports which can be accessed by managers or individuals. While such information is often available in near real-time it would appear to lack the immediacy and efficacy associated with badge or screen-based systems. The capacity for prompt feedback is considered another significant benefit of electronic monitoring systems (D. J. Gould et al., 2011) due to the noted positive effects on hand hygiene behaviours and subsequent patient outcomes (Azim et al., 2016). Pincock et al. (2012) noted how electronic monitoring systems, via the immediacy of feedback, can change the status of hand hygiene results from a periodic compliance check to a "daily performance/quality metric that can be used as a dynamic feedback loop" (p. 24). Of course, it could be argued that as a methodology direct observation is ideally placed to facilitate the delivery of not only immediate feedback, but also clinically contextual feedback that is relevant to the care activity or HCW/patient interaction taking place. In addition, in the Australian context, the use of a mobile device, the direct observation data collection 'app' and the report generating capacity of the NHHI database means a report can be provided within minutes of collecting and synchronising the data (ACSQHC, 2019) . However, as has also been noted, many auditors are reported to be reluctant to provide on the spot feedback due either to a concern as to the response they will receive or a desire to avoid disharmony within the team.

Given that electronic monitoring systems can provide feedback quickly and efficiently, one could conclude that such systems would be ideal for improving hand hygiene compliance. However, as D. J. Gould et al. (2017) cautioned, although the feedback data generated by such systems can be valuable, it is only of benefit if managers and infection control practitioners have the time to analyse and act upon it. Conway et al. (2014) conducted focus groups following the trial of an electronic monitoring system which provided feedback at group level and found that results were "not disseminated widely" (p. 412) and that frontline staff in particular reported that they either did not receive feedback or did so irregularly. Furthermore, even if this feedback is available and the technology is able to deliver relevant and simple compliance data to end users, HCWs and teams need to be motivated to use that information as a basis for actual practice change, otherwise the technology will be of little benefit (Azim et al., 2016; Cantrel, 2016). Conway et al. (2014) also found that their focus groups provided little evidence that the generated data was utilized to promote improved compliance.

DISADVANTAGES OF ELECTRONIC MONITORING SYSTEMS

While many authors advocate strongly for a transition to electronic monitoring systems and see such technology as a solution to all the problems associated with direct observational auditing, there are disadvantages and limitations when analysing and utilising the outputs. Srigley et al. (2014) warn that electronic hand hygiene monitoring systems are "not a panacea" (p. 978) to the problems of hand hygiene compliance monitoring and improvement.

Use of Proxy Measures of Compliance

Perhaps the most significant disadvantage associated with electronic monitoring systems is the apparent inability of many, if not most, to measure hand hygiene compliance according to the WHO 5 Moments definitions. The literature abounds with terms such as 'estimated', 'predicted', 'expected' or even, 'calculated by algorithm'. Measures are frequently described as being proxies or surrogates for the WHO 5 Moments (Boyce, 2017a; McLaws & Kwok, 2018; Pires & Pittet, 2017; Srigley et al., 2013; Venkatesh et al., 2008). Diefenbacher et al. (2020) insist that at best such approaches can only be "sophisticated surrogates" (p. 45). It is therefore important to understand and take into account exactly how an individual electronic monitoring system defines compliance and how this may, and frequently does, differ from the metric used to calculate compliance associated with data collected via direct observation. According to the WHO (2009) Guidelines on Hand Hygiene in Health Care, hand hygiene compliance is expressed as a percentage derived from the division of hand hygiene events by hand hygiene opportunities. That is, how often hand hygiene consistent with the WHO 5 Moment framework was correctly performed, divided by the number of

times that it should have occurred. Electronic systems, by virtue of system parameters, use a variety of measures that differ to those used to calculate compliance via direct observation. There is also significant variation between the measures used by individual systems, so much so that Srigley et al. (2015) quantifies the compliance output from electronic monitoring systems as being "system defined" (p. 52) rather than compliance per see. The WHO 2013 report on electronic systems for hygiene surveillance also noted the differing notions of compliance between various systems and further state that most electronic monitoring systems are "unable to monitor compliance as usually defined" (p. 2).

Systems with a product consumption/dispenser activation focus will generally track only hand hygiene events or in other words the rate or number of episodes occurring. The presumption being that greater product usage or dispenser activity equates to a higher rate of compliance. Although this is generally held to be the case (Cheng et al., 2010; D. J. Gould et al., 2011), some studies have in fact failed to demonstrate a convincing link (Cohen et al., 2016). More complex dispenser activation systems involve the incorporation of an estimated or calculated denominator. Alper (2015) described the use of a software program to calculate the denominator, while the large studies by Steed et al. (2011) and Azim et al. (2016) used the results of extensive 24-hours/day, 7 days/week direct observational audits to derive a hand hygiene opportunity rate. This figure was then adjusted according to patient acuity, bed occupancy and staff levels to provide a context specific denominator. The systems also counted dispenser activation or usage to provide the numerator and an overall hand hygiene compliance percentage was then able to be calculated.

While undoubtedly providing large amounts of data, these methodologies raise several issues. Notably, they are unable to distinguish individual Moments according to the WHO 5 Moments criteria, providing instead an "aggregated rate for all 5 Moments" (Kwok et al., 2016, p. 1476). In addition, all dispenser activations are regarded as "compliant" and there is therefore no way of measuring the appropriateness of the hand hygiene episode. That is, it cannot distinguish whether the hand hygiene occurred at the correct point in the sequence of clinical care in relation to the timing of HCW contact with patients and/or their environment (Cheng et al., 2011; D. J. Gould et al., 2007; Srigley et al., 2014; Storey et al., 2014; WHO, 2009). Contact in this context is inferred rather than measured, hence it could be suggested that the need for hand hygiene remains similarly uncertain, being presumed at best. B. I. Braun et al. (2009) asserts that many electronic monitoring systems "do not link the occurrence of hand hygiene to the opportunity within patient care" (p. 287). This means that they do not determine whether the episode fits into the context of patient care and will be beneficial in terms of interruption of microbial transmission, of if it is essentially a random act of hand hygiene (Helder et al., 2012; Marra & Edmond, 2014; Sodre da Costa et al.,

2013). It is possible to argue that while such systems may indeed prompt staff to perform more hand hygiene, this may not be the correct message to be sending. Rather than simply increasing the number of hand hygiene events overall, it could be argued that increasing the number of appropriate hand hygiene events may be more pertinent. Cohen et al. (2016) notes that "timing and appropriateness of hand hygiene may be more critical for infection prevention than overall frequency" (p. 1494). Similarly, Boyce (2011) asserts that count-based electronic monitoring systems do not "identify specific issues that warrant further education of HCWs" (p. 1020). Another problem is that most count-based electronic monitoring systems are unable to identify which individuals are performing hand hygiene meaning that detailed information as to compliance according to HCW designation is not available. Consequently, the ability to tailor a message to a particular craft group is lost (Edmisten et al., 2017; D. J. Gould et al., 2017; Levchenko et al., 2013). Finally, dispenser activation electronic monitoring systems do not provide any information regarding the adequacy of techniques including glove use (Marra & Edmond, 2014; Ward et al., 2014). What is clear is that dispenser activation or count-based electronic monitoring systems are unable to provide data as to the timing and the appropriateness of hand hygiene behaviours.

Room entry/exit systems have many of the same problems. These modalities calculate a compliance rate by dividing dispenser activations by the total number of room entries or exits as defined and detected by various electronic systems such as light beams, proximity sensors or real-time locational tracking systems as distinct from the criteria of the WHO 5 Moments. Some systems refine this metric further by requiring or limiting according to temporal proximity of the entry or exit to dispenser activation for the episode to be defined as compliant (Cheng et al., 2011; Fisher et al., 2013; Pineles et al., 2014; Pong et al., 2018; Sahud et al., 2012). A number of authors report systems which claim to collect data "corresponding to specific Moments 1 and 4" (Al Salman et al., 2015, p. 120). Or that their system "addresses two of the five Moments" (Cheng et al., 2011, p. 2). The key words here are clearly 'corresponding' and 'addresses' as a review of the studies and the described technology make it plain that the metric used for compliance is hand hygiene upon entry/exit to or from the patient zone rather than before and after patient contact per see. This means that these are proxy measures rather than compliance according to the WHO (2009) Guideline on hand hygiene in healthcare given that the definitions for Moments 1 and 4 are, respectively, 'before and after patient contact' as distinct from 'before and after room entry or exit' (Boyce, 2017a; Pires & Pittet, 2017; WHO, 2009). Furthermore, no electronic monitoring system has yet demonstrated capacity to monitor within-zone hand hygiene. In particular Moment 2, prior to a procedure and Moment 3 after a procedure or body fluid exposure. These categories of HCW-Patient interaction may and often do, require a HCW to perform additional hand hygiene subsequent to their entry to or prior to

their departure from, the patient zone. A. Stewardson and Pittet (2011) warn of the importance of monitoring behaviours and actions that actually "correspond conceptually with patient safety" (p. 1030) and go on to note that while monitoring and promoting hand hygiene prior to door opening may be simple, convenient and indeed technologically possible, this does not mean that it is either useful or desirable in terms of best practice for patient safety. Thus, it is suggested that there is a risk of changing the definition of what constitutes hand hygiene compliance because that is what the technology is able to easily and conveniently monitor rather than defining compliance as adherence to practices which most effectively decrease the risk of microbial transmission. As with dispenser activation systems, badge-based, entry/exit systems are unable to detect if hand hygiene is appropriate to the context even if it correlates with a defined Moment (Hagel et al., 2015). Or as Sahud et al. (2010) phrases it, such systems are unable to "distinguish obligating events" (p. 638). Furthermore, such systems may be unable to detect noncompliance (Helder et al., 2012), or in other words they miss the missed Moments, being unable to recognise that hand hygiene should have occurred but did not. This is principally true of within-zone hand hygiene, particularly Moments 2 and 3 which may be undetectable in terms of requirement and execution using the entry/exit compliance model (Momen & Fernie, 2010).

Some authors do question the importance of monitoring all 5 Moments, advocating that as Moments 1, 4 and 5 make up 80 - 85% of the typical Moments collected by direct observation. In addition, compliance with these 3 Moments is reported as being a reasonable representation of compliance with the remaining Moments. It is therefore seen as sufficient by some authors to collect only Moments 1, 4 and 5 electronically, notwithstanding that, as has been noted, these Moments will essentially be collected as proxy measures (Azim et al., 2016; Boscart et al., 2010; Conway et al., 2014; McLaws & Kwok, 2018).

However, the contrasting view is that all Moments are important and that, as has been noted, "patients don't benefit from partial compliance" (Haas & Larson, 2007, p. 8). Within room compliance, or more pointedly, noncompliance is a concern, as it can expose patients to the risk of microbial transmission from the environment or endogenous infection from their normal flora or colonising pathogens. Kelly, Blackhurst, Steed, and Diller (2015) warn that the risk of within room transmission is "too great to rely on a monitoring system that ignores this component of the process" (p. 901). Furthermore, if only entry and exit hand hygiene is monitored then it may be that the wrong message is being sent in terms of best practice. HCWs may ultimately come to believe that entry and exit are the only times that hand hygiene is actually required. A. Stewardson and Pittet (2011) concur, warning that such approaches may ultimately become counterproductive. Thus, if Moments 2 and 3 are no longer monitored or promoted, the question arises as to whether

compliance will decrease with these Moments and will this decline in turn remain undetected if monitoring excludes these parameters. Pires and Pittet (2017) warn that there is the risk of a departure from the "initial objective of hand hygiene monitoring" (p. 465), that being the interruption of microbial transmission, the consequent reduction in HAIs and enhanced patient safety.

The work of Armellino et al. (2013) is worth considering in this context. These authors report an extensive intervention using an electronic monitoring system which recorded hand hygiene at entry to and exit from all rooms and provided real-time feedback at the HCW group level via public display screens. The 48-week intervention was credited as promoting a sustained hand hygiene compliance increase from 30.43% to 82.26%, however the authors note that there was no correlation between the improved compliance and the HAI rate which remained steady for the duration of the intervention. They also indicate that there was no capacity for their system to monitor within room hand hygiene, be it between patients in a multi-bed room or within-zone Moments such as 2 and 3 for individual patients. It could again be suggested that by focusing on entry and exit hand hygiene HCWs may have in fact reduced their within-zone hand hygiene and that this would have remained undetected due to the limitations of the electronic monitoring systems. While there is no way to verify this with the technology described, it is a reasonable question to consider and certainly an issue that bears further investigation as the potential reason for the failure of HAI rates to fall in a setting with significant increase in hand hygiene compliance.

Momen and Fernie (2010) identified such limitations with many electronic monitoring systems, in terms of both within room/zone hand hygiene, as well as the lack of predictive ability of systems. The latter related to the issue that automated systems are only able to discover a Moment which has occurred, rather than accurately recognise that it needed to happen – this is particularly pertinent to Moment 2, immediately before a procedure. Their research investigated the use of an accelerometer to map nursing activities via pattern recognition, and while the authors concluded that this methodology did show promise, further research was needed to allow the system to predict the need for hand hygiene prior to it occurring and further to issue a prompt if it was not performed accordingly.

Participants in a phenomenological study undertaken by Mackrill et al. (2017) argued that the type of output, in the form of an overall score as produced by most electronic monitoring systems, does not hold meaning for many clinical staff. While acknowledging the shortfalls of direct observation, the participants reasoned that such data does not "reveal specific information about when HH (sic) does or does not occur" (p. 25). Hence, HCWs are unable to relate a single compliance

score to the clinical context within which they should be performing hand hygiene, thus limiting the utility of such output data. The work of Dawson (2015) had similar findings, with participants who regularly received hand hygiene compliance reports noting that a generic, overall hand hygiene compliance score left them feeling "unable to relate received data to clinical practice in their setting " (p. 251), as well as with uncertainties as to how to "move forward" (p. 251) using the data which was also described as having "no meaning". This, again, highlights the importance of detailed and clinically contextual compliance information.

Thus, while electronic monitoring systems provide large amounts of useful data that is often valid and accurate within the parameters of the system's definition of compliance, the output of these systems cannot be directly compared with the compliance rates obtained by direct observational auditing. As Armellino et al. (2012) noted, "the auditing rules [are] not exactly the same" (p. 6). Furthermore, in the Australian context, do they provide data in a form that could be submitted to the NHHI as part of the mandated hand hygiene auditing requirements.

Expense of Electronic Monitoring Systems

The cost of electronic monitoring systems is often cited as a significant disincentive to the use of such approaches as compared to direct observational auditing (B. I. Braun et al., 2009; D. J. Gould et al., 2017; Haessler, 2014). It is important, when considering the financial impacts of an automated system to recognise that the 'cost' may go beyond just the purchase of the system and may be inclusive of a multitude of additional factors. These may include requirements related to installation or infrastructure, including additional network access and capacity along with data storage requirements (Boyce, 2017a; Hagel et al., 2015; McDonald et al., 2018). Consideration must also be given to the cost of any building or structural works that are required to accommodate the system, as well as the financial implications of disruptions to clinical services and HCW workflow. Moreover, the potential impact of loss of productivity due to poor staff acceptance, effects on organisational culture, increased infection risk due to possible exposure to mould or fungus which could be released during building or installation as well as the additional expenses of mitigation strategies, must all be accounted for (Boyce, 2017a; Conway, 2016; D. J. Gould et al., 2007; D. J. Gould et al., 2017; Ward et al., 2014).

The ongoing success of any intervention also requires long-term financial planning and allowances for scheduled maintenance as well as emergency repairs, including the replacements of batteries or malfunctioning or missing equipment. Such a plan is vital to ensure that any system continues to function at the optimum level and that there are no data gaps or losses (Boyce et al., 2017; Hagel et al., 2015; Ward et al., 2014).

Just as there is a large range of different electronic monitoring systems available, so too does the cost of these technologies vary considerably. It is also pertinent to consider that the cost of a system, even a handful of years earlier may no longer be accurate due to a myriad of factors such as new innovations, technological, developments and subsequent decreases in component prices. As a rule, count-based systems are relatively inexpensive to establish and maintain, as well as requiring less in the way of supportive infrastructure (D. J. Gould et al., 2017; Masroor et al., 2017; Muller et al., 2014; Vaidotas et al., 2015) as compared to tag-based electronic monitoring systems which are generally more complex and expensive (Boyce, 2008; Cheng et al., 2011). Tag-based systems have multiple components which frequently include proximity beacons or devices, dispenser monitors, radio-frequency and or Wi-Fi communication links, badges or other equipment to detect and prompt hand hygiene behaviour, as well as the associated software to record, analyse and report results (Al Salman et al., 2015; Boscart et al., 2010; Cheng et al., 2011; Dufour et al., 2017; Srigley et al., 2015). Consequently, it is unsurprising that these systems are considered "expensive and complicated to implement and maintain" (Edmisten et al., 2017, p. 864).

At one end of the costings scale is the simple entry system as described by Fakhry, Hanna, Anderson, Holmes, and Nathwani (2012). This system monitored 4 ward entry doors and comprised of 4 motion activated audio prompts which advised all of those entering the department that they were required to perform hand hygiene. The system was credited with improving hand hygiene incidence from 7.6% to 49.9% of entrants and was quoted as costing $500 and taking "less than half a day to install" (p. 321). In 2012, Sahud described a badge-based entry/exit system with linked hand hygiene dispensers. This system was reported to be associated with an improvement in hand hygiene from 37.2% to 49.1% over a 5-month period. The cost of the equipment was reported as $500 per room and $150 per badge, although no information was given as to additional expenditure for installation or maintenance. In 2014, Storey described a more complex system involving a Wi-Fi linked badge-based system with both proximity and alcohol detecting capacity, as well as immediate feedback through variously coloured lights on the badges. Baseline hand hygiene in the study area was reported to be 21.6%, as defined by the electronic monitoring systems, and peaked at 66.5% during Phase 2 of the intervention. The authors reported that the cost of the equipment was approximately £150 per bed and that annual maintenance costs were £12 per bed.

At the other end of the cost spectrum is the system reported by Armellino et al. (2012). This was a relatively complex system incorporating entry/exit video monitoring with real-time footage review by an external 3rd party provider in India and a near real-time feedback display board. The system was trialled in a 17 bed ICU over 25 months and was attributed as achieving an increase in entry/exit compliance from 6.5% to an average of 87.96% in the maintenance period. The authors

report the cost of the installation of the 21 cameras was US$50,000 but did not provide details of additional costs such as maintenance or the ongoing use of the offsite 3rd party provider to report 24hr a day compliance.

As was noted however, direct observational auditing is also not without financial burden and some authors will leverage this fact when supporting the use of electronic monitoring systems. For example, Geilleit et al. (2018) reported on a system involving ultrasound defined zones, pressure sensors and linked hand hygiene dispensers in an outpatient's department to record and prompt hand hygiene prior to patient contact. The authors contend that the estimated annual cost for such a system hospital-wide would be $31,790, which was less than half the cost of collecting the same volume of data via direct observation. However, consideration must be given to the nature of the data being collected. In this instance, the electronic monitoring systems monitored only hand hygiene prior to patient contact and then potentially only in proxy as there was no certainty regarding the appropriateness of the hand hygiene episode. Hence, at best, this system could be described as capturing surrogate Moment 1 information, whereas direct observation would collect data on all of the WHO 5 Moments, as well as additional data pertaining to technique and clinical context. This is a similar situation with many automated hand hygiene monitoring systems, which as has been noted, record valuable, but nonetheless proxy, information rather than data consistent with the WHO 5 Moments. Thus, caution must be employed when comparing the cost of electronic monitoring systems and that of collecting data via direct observation. This is particularly the case with attempted number for number comparisons. It is undeniable that many electronic monitoring systems will be able to collect vastly greater numbers of hand hygiene events than would be possible with direct observation, however these events are not qualitatively the same.

What may be more important than a consideration of cost per se, is the cost/benefit of the system. D. J. Gould et al. (2011) warned of this, noting that efficacy and accuracy notwithstanding there had been a lack of evidence regarding the use of electronic monitoring systems in routine patient care. Similarly, Ward et al. (2014) cautioned institutions against the installation of costly systems without a guarantee of accurate data or long-term improvements in compliance. Thus, a more expensive data modality which records accurate and meaningful information and is associated with increased hand hygiene compliance and a reduction in HAI may prove worthwhile. In contrast, a methodology of uncertain accuracy and sustainability and for which the impacts on HAIs is unclear, would not be. Sahud et al. (2012) supported a cost/benefit analysis, noting that even though a system may be expensive, the savings associated with preventing "even one hospital-acquired infection need to be built into the comprehensive cost-benefit analysis" (p. 273). Commentary on the topic in the Australian Infection Prevention online forum also acknowledged the expense of

many electronic systems but offered the alternative view that equally as expensive was “using nursing staff to collect highly biased rates” (ACIPCLIST, 2018).

A final note regarding the expense electronic monitoring systems is sounded by McDonald et al. (2018) who reported a monitoring and compliance improvement program using a “pragmatic teenager” (p. 706) who was instructed to provide “hall monitor” (p. 707) style feedback and reminders to staff. This program was reported to have been associated with an increase in compliance with the WHO 5 Moments from 42.7% to 80.9% as recorded by separate covert direct observational auditing. The authors argue that for the cost of set-up and one year of running costs of a typical automated system they could employ their part-time student hand hygiene monitor “52 weeks a year for 8 years” (p. 707).

Accuracy of Data

Many authors argue that the output from electronic monitoring systems is more accurate than the data collected by direct observational auditing due, in part, to the large volume of information and hence a “more comprehensive dataset” (Sahud et al., 2010, p. 638). However, according to Pineles et al. (2014), apprehensions about system accuracy are one of the most common concerns that HCWs express about electronic monitoring systems. Comparisons are sometimes made between compliance rates recorded via direct observation and electronic monitoring systems. However, as has been discussed, this data is collected in not only a different manner but is also subject to different biases and definitions of compliance used. Therefore, it is neither desirable nor appropriate to make direct comparison of compliance percentage results. What is important, however, is that the electronic monitoring systems is inherently accurate. In other words, that it measures what and how it purports to measure according to whatever system-defined compliance metric is relevant to its individual operation. In a systematic review of electronic hand hygiene compliance monitoring systems, Ward et al. (2014) noted that “very few articles assessed the accuracy or predictive values of these electronic systems” (p. 477). Suggesting that accuracy is either not recorded, reported or is potentially assumed in the majority of systems being trialled and used.

Various factors have been identified as adversely impacting on the data collected by automated means beyond the parameters or limitations of system design. This may include issues such as problems with line of site technology and overburdening of, or interference with Wi-Fi or other data or electronic systems. Some devices may become overloaded and be unable to distinguish between multiple simultaneous users, while others may suffer from what Boyce (2017a) refers to as “sub-optimal location granularity” (p. 531).

Badge-based, entry/exit systems are generally unable to detect if hand hygiene is actually required or not. For example, the scenario when a HCW enters a patient room or zone to check upon or talk to a patient but makes no physical contact with them or with their environment (Ellison et al., 2015; Helder et al., 2012). Sahud et al. (2010) found in their study involving the use of a system with an entry/exit compliance metric, that hand hygiene was not required as per the WHO 5 Moments for 8.2% of room entries. Their system, however, defined these room entries or exits to be noncompliant if hand hygiene is not detected by dispenser activation. This can be a problematic message to be sending to HCWs, as it is suggested that the knowledge that a failure to perform entry hand hygiene, even when there is no clinical context for it, may erode the performance of genuinely appropriate and timely hand hygiene. Consequently, HCWs may begin to perform unneeded entry hand hygiene to be defined as compliant, rather than appropriate hand hygiene immediately before patient contact (Moment 1) or immediately prior to a procedure (Moment 2). The system described by Cheng et al. (2011) refines the uncertainty in this regard via the use of a "predefined reference table to predict the probability of patient contact having occurred" (p. 4). The likelihood of contact was indexed by event duration and while still not a perfect solution it was certainly an improvement on the simple inferred contact, entry/exit model.

Another potential inaccuracy of electronic monitoring systems relates to the ability to detect hand hygiene performed in the previous patient zone, when a HCW moves directly to the next patient contact. In this context there is no requirement for additional hand hygiene (e.g. Moment 1) prior to the subsequent patient contact (Ellison et al., 2015; Venkatesh et al., 2008; Ward et al., 2014). Known as 'Double Moments', in the Australian context of direct observational auditing a single hand hygiene opportunity of this nature would be counted twice. It would be considered to be both Moment 4, after patient contact and Moment 1, before patient contact (ACSQHC, 2019) and would be recorded as two compliant or noncompliant hand hygiene events depending on observed behaviour. Some electronic monitoring systems attempt to overcome this issue by using a timing option, in that hand hygiene performed within a certain timeframe or window prior to or following entry/exit will be deemed compliant. The system described by Pong et al. (2018) is an example of this adaptation in that dispenser activation within the time bracket of one minute prior to detected entry and 20 seconds after detected exit constituted a compliant episode as defined by the system. However, this feature does not appear common and hence noncompliance could potentially be recorded in this scenario. This may in turn elicit HCW frustration with the technology or prompt unnecessary hand hygiene by HCWs in attempt to game the system to achieve better rates or avoid real or perceived consequences of noncompliance. A study by Boscart et al. (2010) found that out of 443 Moment 4 (after patient contact) hand hygiene events, 25 proceeded directly to the next

patient contact or could be classified as the so called ‘Double Moments’. In this context, a single hand hygiene episode would be sufficient, providing nothing else was touched between patients, as per the WHO 5 Moments framework.

Azim et al. (2016) also highlights potential accuracy issues relating to dispenser activation systems which use a calculated denominator. The hand hygiene opportunity number is often calculated from a base figure derived from extensive 24-hour/day direct observational auditing as described by Steed et al. (2011) and Azim et al. (2016). If, however it is accepted that data collected by direct observation is skewed by the Hawthorne Effect, then it is possible that the denominator figure is consequently, similarly flawed. Azim et al. (2016) does contend that the continuous nature of the data collection utilised for their study (24 hours a day for a 7-day period using 30 qualified HHA auditors) meant that the hand hygiene opportunity rate was “unlikely to be adversely affected by being observed” (p. 4). Although no explanation for this statement is provided, it is possible that the authors are referencing the acclimatisation effect as described by D. J. Gould et al. (2017) and discussed in Chapter 1 as a potential mitigation of the Hawthorne Effect.

Many dispenser activation systems are also unable to account for hand hygiene performed by patients or their relatives or visitors, nor the inappropriate use of product such as for the cleaning of equipment. Such dispenser usage could artificially elevate the numerator and result in a falsely elevated compliance rate (Azim et al., 2016; Helder et al., 2012; Venkatesh et al., 2008). A small number of studies do in fact report system accuracy. For example, Cheng et al. (2011) found that their system had an error rate of 7.1%. Fisher et al. (2013) found that their system underestimated hand hygiene opportunities by 10.2% and compliance by 5.2%. Boscart et al. (2010) reported that the system they trialled could record 85% of hand hygiene opportunities. However, it is unclear if this was based upon accuracy testing per see or on the entry/exit functionality of the system, the fact that entry/exit was seen as a proxy for Moments 1, 4 and 5 and that further these Moments are believed to make up 80 - 85% all hand hygiene opportunities. Pineles et al. (2014) trialled a badge-based system which in simulation showed 88.5% accuracy. However, when this system was assessed in the clinical setting accuracy dropped to approximately 50 - 60% unless HCWs modified workflow and behaviours to accommodate it. The authors also noted that there was a “counterproductive reduction in HH (sic) compliance” (p. 147) of 32 - 36%. The WHO (2013) review concluded that comparative studies of direct observation and electronic monitoring systems accuracy had “controversial results” (p. 2).

Another important factor regarding system accuracy pertains to HCW beliefs and perceptions. A system may actually be accurate in terms of what and how it measures, but if staff do

not believe it to be accurate then they may not accept, trust or be prepared to reflect, use or act upon the data the system produces (Al Salman et al., 2015; Masroor et al., 2017; McGurkin & Govednik, 2015). In the study undertaken by Al Salman et al. (2015) the authors reported HCWs expressing concerns as to the accuracy of the technology, including an apprehension that they would be blamed for the noncompliance of colleagues. Bouk et al. (2015) reported how, prior to their study in 2013, management did not find the results produced by their product consumption method of tracking compliance credible and that there were frequent arguments about the methodology and results. An alternative compliance metric using a dispenser activation electronic monitoring system as well as education to combat "data denial" was believed to be linked to both improved compliance and acceptance.

The concerns of staff relating to the accuracy of electronic systems may arise due to a lack of understanding as to the technical specifications of the particular system. This may pertain to the fact that compliance is being measured in a different way via the automated technology as compared to the direct observational method with which they are familiar. Concerns may also relate to a lack of understanding that data is now being collected with reduced bias and hence in the absence of the elevating stimulus of the Hawthorne Effect, for example, there may be an apparent decline in compliance. It would appear that in situations where compliance rates decrease in comparison to those collected by direct observation or are lower than expected, HCWs are less likely to trust and accept the data from the electronic monitoring systems (Bouk et al., 2015; Conway, 2016; Kwok et al., 2017). Explanation of these factors, including measurement parameters and likely results, is a recommended solution to this issue (Conway, 2016; Ellingson et al., 2011). However, Kwok et al. (2017) found that even with explanation and involvement, HCWs on one of their trial wards which recorded poor compliance, continued to question the validity of the data. Thus driving home the point that even if the data is accurate according to the tenants of system-defined compliance, HCWs must also believe and accept it to be accurate.

Alarm Fatigue

Alarm fatigue is described as a process of alarm desensitization and subsequent reduced responsiveness to alarms and alerts. It is believed to be due to exposure to excessive alerts in the clinical environment, and in particular, a high level of exposure to false or non-actionable alarms (Cvach, 2012; Sendelbach & Funk, 2013). In the original context, the term alarm fatigue appears to relate to HCW desensitisation to physiologic alerts such as cardiac monitors, ventilators or infusion pumps and much of the literature has this focus. However, it is apparent that the term and the concept is becoming more generally understood and applied. This is relevant to the hand hygiene

context where the phenomenon is regarded as a disadvantage associated with automated systems which incorporate performance or non-performance prompts. Authors use terms such as alarm fatigue, alert burnout and even sign fatigue (Ellison et al., 2015; Hoang et al., 2018; Moller-Sorensen et al., 2016) to refer to the diminishing effect of electronic monitoring systems compliance interventions upon hand hygiene behaviours. Ellison et al. (2015), for example, raised the possibility of alarm fatigue when, during their trial of a hand hygiene monitoring and prompting system, there was an "apparent decay in the effectiveness of [the] audible alarm" (p. 4). The authors noted that this effect followed an initial spike in compliance and a subsequent decrease within 5 weeks of alert instigation, which they attributed to alarm fatigue. An additional compliance decline was noted in a later phase of the trial; however, the researchers were unclear if this was due to an alteration to the prompting/feedback process or was a form of "more delayed onset of alarm fatigue" (p. 4). Overall, their study involved three, back-to-back intervention phases of 5 weeks each, as well as pre- and post-intervention data collection. It is therefore concerning, with regard to long-term system impact and sustained efficacy, that the possibility of alarm fatigue was raised in such a relatively short space of time.

Moller-Sorensen et al. (2016) discussed the possibility of alarm fatigue in their 3-month intervention, although they did not believe they detected any evidence of the phenomena. The authors noted that their study was not sufficiently long enough to "evaluate the long-term effect that "alarm fatigue" may have had on the improvement seen" (p, 339). Similarly, Geilleit et al. (2018) noted that their electronic monitoring systems, which incorporated a variety of prompting options, was only trialled for a "relatively short period" (p. 188). The intervention went for a total of 3 months but included two different prompting formats. The authors recognised the concern that HCWs could have become "accustomed and adapted" (p. 188) in the longer term and that this was not investigated due to the relatively short duration of the trial.

Many reports of hand hygiene compliance raising interventions using or featuring an electronic monitoring system are quite short-term and thus the issue of alarm fatigue is not detected or explored, although the potential is often raised as noted above. The systematic review conducted by Jeanes et al. (2019) found that out of the 71 studies reviewed, 65.3% were conducted for a duration of less than 12 months. An example of a short duration trial would be the 28-day intervention described by Al Salman and colleagues (2015). The 25-month intervention by Armellino et al. (2012) is an exception in terms of duration. It is interesting to note that although the possibility of alarm fatigue is not discussed, the authors do report that there were periodic declines in compliance. These "intermittent fluctuations" were detected by their video-based, real-time feedback electronic monitoring systems, as were the responses to the "subsequent actions taken by

unit leaders to reclaim their high levels of performance" (p. 5). The possibility that the detected declines are an example of alert fatigue or accustomisation should be considered in this context.

Being exposed to a higher number of false or non-actionable alarms is believed to accelerate the onset of alarm fatigue. Momen and Fernie (2010) raised this possibility on the basis that some electronic monitoring systems designs may result in unnecessary or inappropriate prompts to perform hand hygiene. For example, when a HCW enters a room or zone but does not make patient or environmental contact. In this scenario most entry/exit electronic monitoring systems will prompt hand hygiene performance or record noncompliance if it is not performed. However, no hand hygiene is required as per the WHO My 5 Moments framework as there is no transmission or exposure risk. This form of "seemingly irrelevant prompting may lead to more important prompts being ignored" (Momen & Fernie, 2010, p. 394). Alternatively, it could lead to what Azim et al. (2016) refers to as 'gaming', in that HCW will behave, consciously or unconsciously, in a certain way to achieve a good compliance score. There is the possibility that such practice fosters the disconnect between the purpose of hand hygiene, that is the interruption of microbial transmission, and the purpose of the system motivated behaviour, in this case to achieve a good compliance score (Pires & Pittet, 2017). Additionally, the receipt of repeated prompts to perform hand hygiene when it is not required or when HCWs do not believe or understand it to be required may lead to frustration. Levchenko et al. (2011) reports how a focus group participant in responding to their feelings about the reminder prompts provided by the trialled electronic monitoring systems related; "Obviously I did not wash my hands for whatever reason, so don't keep beeping at me" (p. 600), thus illustrating both frustration and potential alarm fatigue.

Suggested solutions to alarm fatigue in the literature relate mainly to the physiologic roots of the phenomenon arising out of monitoring equipment alarms. These include actions such as ensuring that alarm limits are set appropriately, staff are provided with education regarding equipment and appropriate alarms and that electrodes or sensors are correctly applied in order to decrease false alarms (Cvach, 2012; Sendelbach & Funk, 2013). However, there are common general principles which can be applied to hand hygiene monitoring systems. One important consideration is to ensure that system parameters and definitions of compliance are such that false or non-actionable alarms are minimised. That is, the system defines compliance in a way that is not contrary to best practice for hand hygiene and hence HCWs are not being prompted to perform hand hygiene when there is no clinical indication to do so – for example, when entering a patient zone where no physical contact is made (Momen & Fernie, 2010). A. Stewardson and Pittet (2011) noted that the ideal system will, not only remind the HCW to do hand hygiene at the appropriate time in the

context or sequence of patient care but will do so “in a manner that does not become excessively irritating or easily disregarded” (p. 1030).

HCW education is promoted as another way to decrease alarm fatigue. In the hand hygiene context this relates to ensuring that staff understand when they should perform hand hygiene in order to be deemed compliant. This will mean that they are not subjected to multiple prompts and alarms to address noncompliance as they will understand when they should perform hand hygiene and hence by being able to comply with correct practice, they will avoid the need for reminding prompts due to noncompliance.

The question must arise however as to whether alert, alarm or prompting fatigue is ever truly avoidable or whether interventions will always ultimately lose their impact via desensitization and familiarity in the longer term. Studies are clearly needed to discern the potential impacts of alarm fatigue upon the long-term benefits attributed to electronic monitoring systems which incorporate reminders and/or prompts. It is worth recalling that desensitisation to the hand hygiene message is not a new problem. In 1995, Pittet and colleagues at the University Hospital in Geneva utilized ‘talking walls’ to promote and improve hand hygiene compliance. This program incorporated 70 different posters displayed at 250 different locations across the facility. Posters were initially changed twice weekly, and then weekly after the first year of the program (Pittet, 2001; Pittet & Boyce, 2001; Pittet et al., 2000). The point of these frequent poster changes was to keep the message fresh and to avoid what Hoang et al. (2018) called “sign fatigue” (p. 12). This highlighted the importance of the need for persistence and responsiveness in hand hygiene compliance monitoring and promotion. A ‘set and forget’ strategy, which may be encouraged by some automated systems, will clearly be subject to alarm fatigue and waning efficacy and thus the long-term value of such prompt/reminder focused electronic monitoring systems may be questionable and potentially a major disadvantage of such systems.

Staff Concerns About Surveillance – ‘Big Brother is Watching‘

The term ‘Big Brother is watching’ emerged from the dystopian novel, ‘Nineteen Eighty-Four’, first published in 1949 by George Orwell. The phrase has entered the lexicon as an expression of concern about being monitored or watched by higher powers during daily activities (Ryan, 1991; Welsh, Hassiotis, O'Mahoney, & Deahl, 2003). The expression aligns with the beliefs held by those who perceive electronic surveillance in a negative light; seeing the practice as a “sinister Orwellian tool of repression and social control” (Welsh et al., 2003, p. 372). In a less extreme context the term is also used in connection with electronic monitoring systems for hand hygiene compliance to express and illustrate HCW unease about, and response to, automated monitoring of practice.

Haessler (2014) warns that such technologies have the "risk of eroding employee trust by generating a sense of Big Brother is watching" (p. 1). In a series 10 focus groups conducted by Ellingson et al. (2011) regarding HCW perceptions of the electronic monitoring systems they trialled, the "most common response overall was concerns about the "Big Brother" implications" (p. 1093). One participant even was even noted to respond that they felt that such monitoring was an insult to their professionalism.

This failure of HCWs to accept or even feel comfortable with electronic monitoring systems is seen as another barrier to and disadvantage of the use of such technology (Masroor et al., 2017; Pineles et al., 2014). McGurkin and Govednik (2015) warned that "human factors can hinder automation" (p. 358). While R. J. Holden and Karsh (2010) warned that if staff do not accept a healthcare technology, the result may be "under use, resistance, work arounds and overrides, sabotage and even abandonment" (p. 159). Conway (2016) suggested that HCWs distrust of electronic monitoring systems can even lead to a reactionary refusal to change their hand hygiene behaviour.

Major concerns of the 'Big Brother' type regarding the use of electronic surveillance of hand hygiene practice seem to be related to 2 main themes: privacy and potential reprisals for noncompliance. Invasion of privacy is frequently cited in the literature as a significant concern and barrier to acceptance (Boyce, 2017a; Conway, 2016; Srigley et al., 2015). Al Salman et al. (2015) relate how some participants in their electronic monitoring systems trial saw the technology as an invasion of privacy and a pretext for management to monitor and spy upon them.

Related to privacy concerns are those surrounding data confidentiality, who will have access to data, as well as the potential consequences of any detected or recorded noncompliance. The phrase 'potentially punitive' appears frequently in the literature in relation to HCW concerns as to how the data from electronic monitoring systems may be used (Conway et al., 2014; Ellingson et al., 2011; Larson, 2013; Ward et al., 2014). Fear of being named or singled out as being noncompliant was also cited (Larson, 2013; Storey et al., 2014) as was the fear that the data might be used in annual performance evaluations (Boyce, 2011, p. 1024). One participant in the focus groups conducted by Ellingson et al. (2011) asked "are they going to use it to fire you?" (p. 1039) illustrating concerns regarding potential reprisals.

The degree to which these concerns impact on HCW acceptance of electronic monitoring systems are dependent on many factors as they do not automatically arise with the implementation of electronic monitoring systems technology, or even within all wards in the facility where an electronic monitoring systems is introduced. Levchenko et al. (2013) note that participants in their

trial “did not raise any privacy or data confidentiality issues” (p. 502). While Cheng et al. (2011) reported that participants in their study found the trialled electronic monitoring systems acceptable. System design and functionality seem to have a significant impact in terms of ‘Big Brother’ concerns. For example, HCWs seem to demonstrate far greater acceptance of badge-based systems which ‘tag’ entry and exit into and out of zones, than of ‘tracking’ systems which can identify their geographical and temporal locations. That is, where they were and when they were there (Conway, 2016; Edmisten et al., 2017; Masroor et al., 2017; Welsh et al., 2003). Ellingson et al. (2011) documented “universal unease” (p. 1094) in relation to electronic monitoring systems able to track HCWs by time and location and relate how one focus group participant responded stated; “it pushes the limits or something… it just doesn’t feel right” (p. 1094). It was made clear that while an entry/exit tagging system might be acceptable, locational tracking was something that many HCWs struggled with.

Another feature of system design which may impact HCWs acceptance and feelings of being watched relates to the level to which individual HCWs can be identified by the system. HCWs showed far greater levels of acceptance of and comfort with systems which used generic tags, provided only grouped data such as overall entry/exit numbers or only monitored compliance by HCW designations or departments (Al Salman et al., 2015; Kwok et al., 2016; Monsalve et al., 2014). A number of studies included clear provisions that individuals could not or would not be tracked and that individual compliance would not be recorded as a means to increase HCW acceptance of the technology. Al Salman et al. (2015) related how participants in their study expressed relief that individual results would not be reported to management and went on to suggest that there would have been a higher level of resistance with the system if that had been the case.

Similarly, the manner in which feedback of data from the system is delivered can also affect HCW acceptance of an electronic monitoring systems in relation to negative feelings of being watched, monitored and potentially punished. The ability to provide one-on-one feedback is heralded as a major advantage of direct observation, yet a number of authors recommend group level feedback of electronic monitoring systems data so that the individual does not feel singled out and negative feelings of being watched or monitored are not promulgated (Bouk et al., 2015; Conway et al., 2014; Larson, 2013). However, as has been discussed, failure to monitor compliance at the individual level may be associated with decreased rates of hand hygiene adherence and decreased personal responsibility for practice (Cheng et al., 2011). The work of Smiddy et al. (2019) may also support the contention that group feedback is less effective than individual in raising compliance. In their study, a statistically significant and sustained increase in hand hygiene compliance was not achieved until after the feedback process was changed from group to individual. In the initial phase, medical staff were provided only with the hand hygiene compliance rate of the

entire team. In the later phase, which was temporally linked to improved compliance, individuals were given both confidential individual compliance results, as well as anonymised peer data. It is worth considering, as Conway (2016) discussed, if the focus is on developing a team culture and relationships and on having the team (be it ward, unit or HCW group) self-regulate and own their hand hygiene compliance, then monitoring and feedback at the group level may be preferred.

When data is available at an individual level HCWs may feel uncomfortable with the confidentiality and security of the data. Most frontline HCWs who took part in the study by Ellingson et al. (2011) felt that they, rather than managers, should be the recipients of their compliance results. Such concern surrounding who will see the compliance data and how it will be used appear to enhance the negative perceptions of and attitudes towards electronic monitoring systems. Hence, a number of authors highlight the imperative of a positive psychological safety culture as a way to minimise feelings of distrust and 'Big Brother' in relation to electronic monitoring systems (Bouk et al., 2015; Boyce, 2017a). Conway (2016) stressed the importance of a just culture, of acknowledging and learning from mistakes and of balancing that with the need for disciplinary action if individual feedback is to be given and negative feelings are to be avoided.

Positive leadership can do a great deal to overcome the negative beliefs associated with electronic monitoring systems. This was evidenced in a number of studies, in particular the works of Kwok et al. (2017) and Al Salman et al. (2015), where staff on wards in the same facility with similar demographics and the same automated system had vastly different responses to surveillance. Al Salman et al. (2015) reported on a trial of an electronic monitoring systems performed in two 8-bed units. In the first unit, compliance rose from 60% to 82% and the staff were positive and engaged with the technology. In contrast, the second unit with the same system demonstrated only a modest increase in compliance from 60% to 70% over the duration of the study. Staff on this unit were described as resistant, sceptical and prone to making negative criticisms. The HCWs on the second unit reported discomfort in relation to being monitored in contrast to the staff on the first unit who made frequent requests for feedback on their compliance rates. Similarly, Kwok et al. (2017) examined the differences in response to an automated monitoring system on two similar wards. One ward showed a peak compliance increase to 66% from a baseline of 49% as defined by the electronic monitoring systems. In contrast, the compliance rate on the second ward remained fairly steady at 28 - 34% over the duration of the intervention. Their work explores the differences in social cohesion of the two wards. On the first ward, it was noted that there were strong team working relationships, positive and enthusiastic role models who supported the trial technology and a strong sense of engagement with the electronic monitoring systems. In contrast, HCWs on the second ward were described as having a defensive culture which was more physician orientated. Staff on this ward

were also identified as being very negative towards and distrustful of the electronic monitoring systems. The Manager was noted to have questioned the “authenticity” (p. 5) of the compliance data provided by the system. These reports serve to highlight the difficulties inherent in the introduction of an automated compliance monitoring system. Negative feelings in relation to being monitored may clearly impact the acceptance, effectiveness and ultimately success of such interventions.

Furthermore, it is important that leadership is open and clear about the purpose of any electronic monitoring systems. Having unambiguous policies and procedures in place so that frontline HCWs will feel comfortable with the technology and the intent behind its introduction has also noted to be important in reducing negative responses (Conway, 2016; Ellingson et al., 2011). The provision of education and information is similarly associated with a reduction of negative perceptions and an increased acceptance of electronic monitoring systems. Information as to how the system will operate, how it will calculate compliance and what the expected benefits are has been shown to decrease fear and uncertainty in relation to being ’monitored’ (Conway, 2016; Ellingson et al., 2011). Al Salman et al. (2015) noted a positive reaction to the provision of explanatory education as to the benefits to both patients and HCWs which would result from improved compliance secondary to the trialled monitoring system in their study. However, although the positive effect was noted, the authors do concede that this was not 100% effective as resistance to the system “never ceased” (p. 123). In contrast Clack, Scotoni, Wolfensberger, and Sax (2017) found that when an explanation, methods and purpose of their study was given to patients and HCWs, objections to filming were “rare” (p. 7).

It is also worth considering the stance of Daniels (2012) who takes the position that if HCWs are compliant with best practice they should not object to monitoring that will support this, noting “the trust that patients place in the healthcare team to “first do no harm” demands both transparency and accountability” (p. 1489). Thus, it follows that if there is the potential to have a system which can accurately detect who is and who is not compliant with best practice hand hygiene behaviour then do we not have an ethical obligation to utilise it? As Daniels (2012) urges, “the time has come to move forward and hold ourselves accountable” (p. 1489).

A key point to consider is that, even with education, explanation and HCW buy in, even with positive leadership, lack of individual tracking and reporting, clear policy and procedures around data use and security in the setting of an open and positive safety culture, there is no guarantee that an electronic monitoring system will be accepted or will be seen as anything other than an example of ‘Big Brother is watching’. It is therefore important that this limitation of electronic technologies is

considered as part of any strategy surrounding the use of an electronic monitoring systems in clinical practice.

THE APPLICABILITY OF ELECTRONIC MONITORING SYSTEMS TO SOLVING THE RESEARCH PROBLEM

It is clear, that while dispenser activation, counter-based electronic monitoring systems have much to recommend them, they do not collect hand hygiene compliance data in a manner consistent with the requirements of the NHHI for submission. Hence, despite the value of the information provided by these systems, this technology is not such that it would be useful in answering the current research question. Similarly, while the tag-based systems do indeed provide valuable data per see, the technology is not such that the derived output of the system mechanics would be useful in answering the current research question either. This leaves video-based monitoring systems.

VIDEO-BASED MONITORING SYSTEMS – A POTENTIALLY USEFUL CATEGORY

Another category or subset of electronic monitoring systems, and one which may prove promising, is the so-called video-based monitoring systems or VMS. Video-based systems appear to be less frequently used and described than dispenser activation or locational systems. To qualify as a VMS, such systems must involve the recording of HCW hand hygiene behaviour and the subsequent evaluation of the footage by an auditor to establish compliance according to a predetermined compliance criteria (Armellino et al., 2012; Armellino et al., 2013; McLaws & Kwok, 2018). Review of the footage may take place in real-time, near real-time or be quite delayed and may be performed by internal or external auditors. Similarly, feedback may be relatively immediate or delayed and may be individualised or more general in nature depending on the specific system design (Armellino et al., 2012; Armellino et al., 2013; McLaws & Kwok, 2018).

While VMS are the least common of the electronic hand hygiene surveillance modalities described in the literature, and despite the apparent more limited application to the problem of hand hygiene compliance measurement, there is in fact an enduring history of the use of video surveillance in healthcare as an important quality assurance tool (Brooks, Phipson, Potgieter, Koertzen, & Boffard, 1999; Jacobs, Duncan, Street, & Murray, 2010; Peltier, 1969). By recording and analysing actual clinical practice, it is possible to achieve “valuable insights for enhancing patient safety through improvements in the process of care” (Weinger, Gonzales, Slagle, & Syeed, 2004a, p. 136). Video recording provides rich data and allows detailed observation and review of the current situation, which Jacobs et al. (2010) argues is the “first step in continuous improvement” (p. 725). Hu

et al. (2012) also see video recording as an important tool to allow HCWs to reflect upon their own performance, describing this methodology as “unparalleled” (p. 21).

The use of video recording in healthcare is not a recent phenomenon, with its use in the Emergency Department in 1969 as a quality improvement modality being one of the earliest examples of the approach (Peltier, 1969; Peltier, Geertsma, & Youmans, 1969) Similarly, in 1999 Brooks et al. (1999) described how they had been utilising video recording of all trauma resuscitations for “a number of years” (p. 1125) as an educational and quality improvement tool. While in 2004, Weinger et al. (2004a) described the process of developing a VMS for intraoperative recording. In 2007, Xiao et al. (2007) utilised a VMS to record all Central Venous Catheter (CVC) insertions in an ED of a trauma centre in Maryland (USA). Although the purpose of the recording was to compare the efficacy of different training methodologies, the authors describe how the recording method resulted in excellent data with which to monitor procedural compliance.

Video recording has also been used in numerous other healthcare settings, including fluoroscopy procedures (Jacobs et al., 2010) where continued performance improvement was documented. Rex et al. (2010) describe the use of a VMS to record colonoscopies where the system trial was associated with improved mucosal inspection time and efficacy. While Hu et al. (2012) described the recording of complex gastrointestinal surgical procedures and a subsequent one-to-one review, feedback and coaching process which was seen as an efficient, effective and valuable educational and quality improvement process. VMS have also been used in operating theatres. Overdyk et al. (2016) described how a “real time” VMS was used to monitor compliance with surgical safety checklists, including sign in/sign out and turnover times with documented improvements in all metrics. Similarly, Pedersen, Getty Ritter, Beaton, and Gibbons (2017) reported the use of a similar real-time system in the operating room which was associated with a significant improvement in turnaround time. Although the authors cite the cost of the system as exceeding US$200,000 p.a., they noted that the value of the time savings in the first month was greater than this amount and hence the value of, and potential for, such technology was readily apparent.

Closer to the infection prevention context is the work of Xi et al. (2016), who utilised live video recordings of PPE donning and doffing in an Ebola treatment centre. The object of their system was to ensure staff safety through the identification of practice breeches during the donning and doffing processes, although within room care was not recorded. The cameras made possible the audit of PPE compliance as compared to best practice and allowed for feedback and education. The authors reported that as a consequence of the intervention there was a statistically significant decrease in the error rate, particularly with regard to doffing which represented an increase in HCW

safety. More recently the work of Curtis et al. (2022) explored the use of video surveillance for PPE doffing at the Howard Springs COVID 19 Quarantine Facility. This study identified breeches in the doffing procedure including missed or inadequate hand hygiene.

In a similar, but perhaps more routine context, cameras are increasingly being utilised within healthcare facilities to monitor staff safety more generally, such as Security CCTV or body cameras, or for patient falls or behavioural management. Given the identified prevalence of video monitoring in healthcare more generally for non-infection prevention purposes it is logical to suggest the potential for repurposing existing footage to address such issues. The work of Brooks et al. (1999), Haac et al. (2017) and Grabowski et al. (2018) provides examples of the utility of this practice. Brooks et al. (1999), for example, described how footage recorded for the purposes of trauma resuscitation review was subsequently analysed to assess compliance with universal precautions including the use of PPE and hand hygiene. The footage was able to identify problems, as well as subsequent improvements following an educational intervention. In a similar vein, Haac et al. (2017) reviewed footage recorded in the trauma resuscitation unit of a Maryland hospital. All resuscitations at the unit are automatically recorded via three cameras located within each bay for quality and training purposes primarily related to resuscitation techniques. However, the reported study involved the review and analysis of the footage from 50 randomly selected events to assess hand hygiene compliance according to the WHO 5 Moments framework. The review was able to identify 1034 hand hygiene opportunities as well as to elicit contextual information relating to both compliance and noncompliance and glove use. Grabowski et al. (2018) conducted a study of sink use in an ICU in Virginia. The focus of this investigation was on the development of multi-resistant biofilm in sink water trap reservoirs and whether this related to sink use behaviours such as the disposal of nutritive liquids. Interestingly, the study identified that less than 5% of sink interactions involved hand hygiene and while the camera placement limited the availability of information relating to compliance that was able to be elicited, the authors did report that useful information pertaining to hand hygiene practice was still able to be derived from the footage.

In terms of the use of VMS and video technology intended primarily for the assessment and analysis of hand hygiene behaviours, the study by Jay, Comar, and Govenlock (1999) is perhaps one of the most frequently cited in the literature. This much referenced work involved placement of cameras in 40 domestic (home) kitchens rather than a healthcare facility. The recordings were able to document inadequate hand hygiene in terms of frequency and technique as well as poor environmental cleaning practices. Aside from the identified health risks and hygiene deficits identified, an interesting aspect of the study was the degree to which recorded behaviours differed from the subjects self-reported practices.

A number of authors have reported the use of VMS to assess and improve hand hygiene, particularly hand washing, technique. Shah, Patel, Shah, Phatak, and Nimbalkar (2015) installed motion-sensitive cameras at the entry sink of the Neonatal Intensive Care Unit (NICU) at a hospital in Gujarat (India). Footage was reviewed for compliance according to the WHO hand washing technique criteria. Performance of 1081 handwashing episodes was captured, and performances were ranked as excellent (37.3%), acceptable (48.2%) and not acceptable (14.5%). Valuable information as to practice gaps were able to be obtained for future improvement interventions. Hoang et al. (2018) also described the placement of cameras at the entrance sink of a NICU, this time in a hospital in the US. This system not only recorded HCW hand washing for later analysis, but also included an instructional video with demonstration of correct technique as well as a timer in order to promote appropriate wash duration. Hand swabs were also taken, and the system was credited as being associated with an improvement in both duration and technique of hand washing, as well as a reduction in microbial load on the hands of participants. In 2011, Ghosh, Lacey, Gush, and Barnes (2011) described the use of a complex commercially available VMS called the 'SureWash' system (Lacey et al., 2019). This technology incorporated real time video recording of hand washing practice with a software algorithm able to analyse and provide immediate feedback of compliance with correct technique. The authors reported that this system was associated with a greater than 156% increase in hand washing frequency and a greater than 703% increase in adherence to correct technique.

In a variation of compliance with correct technique, Stackelroth, Sinnott, and Shaban (2015) used video to study appropriate hand hygiene product selection in an emergency department in Queensland, Australia. The authors noted that there was a 6.2% error rate where HCWs used an inappropriate product for hand hygiene and an additional 5.8% displayed hesitation regarding product selection. Hesitation was defined as occurring when a HCW moved towards an incorrect product initially and then self-corrected. Although this system was unable to measure compliance according to the WHO framework it did collect valuable data which allowed the authors to recommend changes to and standardisation of hand hygiene product placement as a means of enhancing compliance.

The use of VMS to record and/or promote contextual or temporally correct hand hygiene has also been reported. Perhaps the most notable system is that described by Armellino et.al in 2012 and again in 2013. This elaborate system was installed initially in a Medical ICU in the United States and then subsequently in a nearby Surgical ICU. The technology incorporated motion sensor cameras at all doorways with views of sinks and ABHR dispensers. Live footage was transmitted to independent auditors and real time compliance rate feedback was provided via electronic display

boards. As has been noted, the compliance metric for this system was room entry and exit with the additional temporal requirement that the HCW remain in the room 60 seconds or more for hand hygiene to be required. If the episode was thus identified as a hand hygiene opportunity, a hand hygiene action (wash or rub) needed to occur within 10 seconds for the event to be deemed compliant. Therefore, compliance as defined by this system was not, strictly speaking, as per the WHO 5 Moment criteria. The rationale for not placing cameras within the patient zone was to "protect the patient privacy" (p. 925), however the result was that within-zone hand hygiene, particularly Moments 2 and 3 were not recorded. The system was credited with achieving a sustained increase in compliance, as defined by the system, from an average baseline of 6.5% to 87.9% during the maintenance phase.

The works of Diller et al. (2014), Clack et al. (2017) Sanchez-Carrillo et al. (2016) and Diefenbacher et al. (2020) are the only ones identified to use a VMS to measure compliance according to the WHO 5 Moment framework and indeed are perhaps the only examples of a type of electronic monitoring systems with such capacity. Interestingly, the first 3 studies did not have hand hygiene compliance monitoring as the primary aim of the investigation. Diller et al. (2014) placed cameras within patient rooms to record hand hygiene for 26 individual patient admissions. The cameras were wide-angled, motion-activated and infrared equipped and were positioned such that they captured the doorway, sink and ABHR dispensers. Audio was not recorded. Patient consent was obtained and signage displayed to inform HCWs and visitors that video recording was occurring. The capacity to cover cameras during private activities was available and was reported to have occurred for 9.6% of the potential recording time overall. The aim of the study was to validate the denominator data collected by direct observation data collected as part of the HOW2 study described by Steed et al. (2011) rather than to monitor hand hygiene compliance behaviour per see. It is clear, however, that the nature of the footage recorded made the measure of hand hygiene practice according to the 5 Moments criteria possible, although the use of a single camera, rather than an array prevented the capture of hand hygiene before and after the patient zone. The study highlights the potential for VMS within room cameras to capture data such that submission to the NHHI would be possible. Another example of a VMS which resulted in footage able to measure compliance according to the 5 Moment criteria is the work of Clack et al. (2017). Once again, the primary aim of the study was not hand hygiene compliance measurement, but rather, to "delineate true hand transmission pathways in real life healthcare settings" (Clack et al., 2017, p. 1). The study involved 10 HCWs (8 Nurses and 2 Doctors) who wore a head-mounted camera for a 70-minute period during a day shift. Cameras were angled downward to track participants' hands. Although the resultant data was coded to criteria different to that of the 5 Moments and would be considered

subject to various biases due to the voluntary nature of participation, the limited day shift sample times, short duration, as well as the overt nature of the data collection, it is again clear that there was potential to measure hand hygiene compliance according to the 5 Moments criteria. The study by Sanchez-Carrillo et al. (2016) involved the placement of cameras in an open plan haemodialysis unit. Continuous recording took place, and the footage was reviewed to assess compliance with hand hygiene practice according to the WHO 5 Moments criteria. Although the technical capacity of compliance monitoring was clearly demonstrated, the aim of the project was to improve hand hygiene compliance via the provision of education and feedback for HCWs through video reflexivity. Each participant was presented with individualised footage to demonstrate correct and incorrect practice and in a private one-to-one session encouraged to reflect upon and learn from their recorded practice. No measurement efficacy, accuracy and cost-effectiveness of the process was reported. Diefenbacher et al. (2020) conducted a study involving the use of body cameras to record and audit hand hygiene practice during simulated standardised patient care activities. The study demonstrated that auditing according to the WHO 5 Moments was possible and the authors concluded that the approach was feasible.

Technical and Functional Aspects of Video-Based Systems

Video-based systems for monitoring a variety of HCW behaviours including hand hygiene, come in many forms and with a range of parameters. Srigley et al. (2013), in describing VMS noted that: “To qualify as a VMS, the system must involve the recording of video within a patient care area with evaluation of the video by an internal or external observer using a specified definition of compliance.” (p. 3).

In terms of the technical aspects of VMS used to record and assess HCW practice, a number of features seem common. Aside from the small portable head- and body-mounted cameras utilised in the studies by Clack et al. (2017) and Diefenbacher et al. (2020) respectively, the majority of systems involve fixed cameras. Where monitoring takes place in an operating room or procedural suite, placement has also been documented inside theatre lights or incorporating the feeds from endoscopes or other devices (Hu et al., 2012; Rex et al., 2010). In some studies, cameras were placed above hand basins, particularly where sink behaviours or hand washing techniques were a focus of the investigation (Grabowski et al., 2018; Hoang et al., 2018; Nishimura, Kagehira, Kono, Nishimura, & Taenaka, 1999; Shah et al., 2015; Stackelroth et al., 2015). While other studies saw the placement of cameras at, or above doorways (Armellino et al., 2012; Armellino et al., 2013). In settings with open plan clinical areas, such as the NICU described by J. Brown, Friese-Fretz, Luckey, and Todd (1996) and the Dialysis Unit by Sanchez-Carrillo et al. (2016), cameras were able to be placed to

allow the simultaneous capture of multiple patient zones. Haas and Larson (2007) suggest that "technically, video cameras are best suited to open plan units where many patient care areas can be viewed on camera" (p. 8). Another approach is to incorporate multiple cameras to capture a more complete picture of HCW behaviours. For example, as many as three different cameras were reported in a single theatre, procedure room or PPE donning/doffing area (Hu et al., 2012; Weinger, 2002; Weinger et al., 2004a; Xi et al., 2016). Other studies have utilised a single camera with a wide-angle view, again facilitating the capture of the greatest possible proportion of the clinical area (Brooks et al., 1999; Diller et al., 2014; Overdyk et al., 2016) with cameras most commonly placed on ceilings or high on walls.

The use of both continuous recording and those triggered by motion detector technology have been reported, the latter approach being favoured as a way or reducing the volume of footage being recorded, stored and needing to be reviewed (Brooks et al., 1999; Diller et al., 2014; Grabowski et al., 2018; Overdyk et al., 2016; Pickering et al., 2014; Stackelroth et al., 2015). The system described by Armellino et al. (2012) was perhaps unusual in that continuous recording was employed but a with a motion detected time and date stamp being inserted into the footage with each detected entry or exit.

Systems designed to record overnight were reported by Diller et al. (2014) and Grabowski et al. (2018), describing the use of infra-red technology. Twenty-four-hour recording may help to ensure a complete data set, unlike direct observation which rarely occurs at night. Some systems were described as being designed to be deliberately low resolution so as to prevent or reduce individual HCW identification (Hu et al., 2012; Pedersen et al., 2017). Weinger et al. (2004a) utilised post-production de-identification processes where HCWs faces were obscured with coloured dots. In contrast, Sanchez-Carrillo et al. (2016) sought to specifically identify individuals and to utilise the recorded footage as a form of confidential, personal reflective feedback on practice. Most systems deliberately did not record audio stream, although this was noted in two studies undertaken in the Operating Room and one from the Emergency Department. In these instances, the verbal interactions and communications between team members were seen as an aspect of the analysis and review process, which centred on clinical decision making (Brooks et al., 1999; Hu et al., 2012; Weinger et al., 2004a). The use of video recording as a means of assessing teamwork and communication skills has been reported as a positive and effective educational strategy (Andersen & Adamsen, 2001; Scott, Watermeyer, & Wessels, 2020).

In the majority of studies, footage was recorded and then later reviewed. In some instances the review took place relatively quickly, for example, Jacobs et al. (2010) described how in their

setting the recordings were “available for review immediately after the procedure” (p. 727). Other authors reviewed and reported upon the footage only at the conclusion of the study (J. Brown et al., 1996; Nishimura et al., 1999). An increasingly common, although as has been noted, expensive, methodology involves real-time review of compliance by remote third-party auditors. Such systems have been trialled and described by Overdyk et al. (2016) and Pedersen et al. (2017) in the Operating Room setting and by Armellino et al. (2012) in relation to hand hygiene compliance. These systems are both elaborate and expensive to install and run, with Conway et al. (2014) suggesting limited practical use outside of research settings. Pedersen et al. (2017), however, argued that in their study the cost-benefit analysis clearly demonstrated that the savings achieved through enhanced efficiency far exceeded the both the cost of the system itself as well as the ongoing running costs.

Advantages of Video Monitoring Systems

Video-based systems for the monitoring of hand hygiene compliance have several advantages over both the gold standard direct observational methodology, as well as other forms of electronic surveillance. Like other electronic monitoring systems, video-based technology has the capacity to collect data continuously, particularly if infrared or low light technology is utilised. This capacity can result in large amounts of data being collected with minimal human intervention or resource requirements (Diller et al., 2014; Haas & Larson, 2007; Sanchez-Carrillo et al., 2016). Sanchez-Carrillo et al. (2016) notes that their system was able to collect far more Moments per hour that was possible using direct observation. The authors report that on average, human auditing was able to record 10.2 Moments per hour as compared to 39.9 per hour using recorded footage.

It is also contended that because the video system will record all practice occurring within the field of the camera that both selection and observer bias is eliminated (Diefenbacher et al., 2020; Dufour et al., 2017; Srigley et al., 2013). Jacobs et al. (2010) described VMS as “impartial scribes” (p. 728) while Hu et al. (2012) noted that such technology decreased bias and partiality. Overdyk et al. (2016) cited the benefits of objectivity and accuracy that such systems confer. Stackelroth et al. (2015) noted that the use of such systems may mean that “observer biases and sampling problems associated with direct observation may be ameliorated” (p. 68). The use of the word ‘ameliorated’ is both interesting and telling as it supports the notion that while data collected via a VMS is far less subject to biases, it is not considered a form of data collection wholly free from them. Haas and Larson (2007) concur, warning that unless the entire ward, unit or department is monitored, then not all HCW behaviour is captured. It is contended, however, that such methodology will represent an improvement in terms of the scope and breadth of data collected as compared to direct observational auditing.

Accuracy is another advantage attributed to VMS. Nishimura et al. (1999) described their system as having the capacity to collect “hard facts” (p. 368) while Hu et al. (2012) noted how “the fidelity of the exercise to real practice is irrefutable” (p. 122). Ghosh et al. (2011) cited the problems of fast-paced hand movements, as well as obstructed views as potentially impairing the ability of human auditors to accurately collect data. Clack et al. (2017) concurred, citing the impacts of “fast paced care” (p.2) on the accuracy of data collected by direct observation. Polit and Hungler (1999) argued that a human observer will never be able to capture all information in any given situation, while Latvala, Vuokila-Oikkonen, and Janhonen (2000) noted “videotaped recordings are complete compared to human observations” (p. 1254). Fries et al. (2012) pointed out “even attentive observers who are diligently recording rates may capture different versions of reality” (p. 694). It is contended that video footage can therefore provide a greater degree of certainty as to actual HCW practice. This is enhanced via the ability to pause, replay or review in slow motion to confirm practice and compliance. This functionality is seen as one of the major benefits of such systems by virtue of the high level of precision it allows (J. Brown et al., 1996; Clack et al., 2017; Hoang et al., 2018; Hu et al., 2012; Latvala et al., 2000; Sanchez-Carrillo et al., 2016). Additionally, Pickering et al. (2014) described how “footage could be analysed at increased speeds” (p. 7) meaning that staff time required for data analysis was significantly reduced. Hu et al. (2012) estimated a 50 – 80% time saving in data review due to the ability to fast forward the footage when appropriate, hence supporting the contention of enhanced efficiency related to video monitoring technologies. Recorded footage may also be reviewed at a more convenient time as compared to direct observation data gathering, which typically occurs during the day shift on weekdays. The rationale for selecting this time is that the clinical areas are the busiest and larger amounts of hand hygiene are being performed and hence data gathering is considered most efficient. However, as has been discussed, this practice can not only foster selection bias but can potentially create conflict for local, ward-based auditors who may have dual clinical and auditing roles (Boyce, 2017a; Daniels, 2012; Haas & Larson, 2007; Kwok et al., 2016; Storey et al., 2014; Yin et al., 2014). Validity of the results may be further enhanced by the use of multiple auditors to assess the data independently, allowing for the improvement of inter-auditor reliability (Diefenbacher et al., 2020)

Video recording of hand hygiene behaviours also raises the possibility of utilising external or offsite auditors to review and rate compliance (Hu et al., 2012; Pickering et al., 2014; Stackelroth & Shaban, 2011). Such a practice would have the potential to reduce the biases which have been attributed to local, particularly ward-based, auditors (Dhar et al., 2010; Pan et al., 2013; Srigley et al., 2014; Talbot et al., 2013). As Makary (2013) notes, remote or external auditors may be “removed from the local department’s politics” (p. 1151) and hence not as subject to the influences and biases

to which the ward-based auditors may be prone. In addition, Makary (2013) goes on to suggest the potential to "draw on the collective efforts among multiple institutions" (p. 1591) in the auditing process, thus raising the possibility of wards, departments or facilities sharing auditing resources for greater accuracy and efficacy in data review. Stackelroth and Shaban (2011) also note the potential benefit of such an option, suggesting remote review as a potential solution to the problem of hand hygiene auditor training and retention in small, remote facilities.

Video recording of HCW practice also has the ability to capture rich data which in turn has the potential to be used for a variety of quality improvement indications. This capacity was demonstrated with the repurposing of resuscitation footage to assess compliance with infection prevention practices as described by Haac et al. (2017) and Brooks et al. (1999). In the hand hygiene context, there is the potential for data to be collected for not only the purposes of compliance with the WHO 5 Moments, but also to provide information regarding several related behaviours. This could include assessment of technique and duration of hand hygiene events, as well as correct product selection and usage (Diefenbacher et al., 2020; Sanchez-Carrillo et al., 2016; Stackelroth et al., 2015). Unlike some electronic monitoring systems, video-based systems can identify specific individuals. This can be beneficial if outlier noncompliance is suspected or identified, particularly in scenarios where the noncompliance of one or a small number of individuals is skewing the overall results of an otherwise well performing team. Hornbeck et al. (2012) highlighted the importance of individual HCW behaviours noting that their study identified significant differences in the frequency, nature and duration of HCW-patient contacts. With some staff having very little patient contact while others were what was described as peripatetic or "highly connected" (p. 1556). The authors contended that on a ward with an otherwise generally high level of compliance but with a small cohort of poor performers, they "may still have difficulties controlling the spread of infection" (p. 1556) despite the high overall score, thus highlighting the importance of individually targeted feedback and remedial action where required. Sanchez-Carrillo et al. (2016) described how participants in their study were provided with confidential one-to-one feedback of both compliant and noncompliant practice. The authors reported that care was taken to ensure sessions were non-punitive and indicated that the use of footage to illustrate individual practice, both good and bad, was particularly meaningful. This process, therefore, allows for the support of individual staff who are underperforming by identifying specific and clear areas for improvement. Other authors reported using recorded footage in a similar manner. Brooks et al. (1999) described the use of recorded footage as an "effective educational tool" (p. 1128). While the study by Hu et al. (2012), based in the operating suite, also incorporated feedback which the authors described as a "postgame analysis" or "video-based coaching" (p. 122) session. This method was reported as being

well received by participants who deemed it beneficial to their practice. In particular, being able to review their actual behaviours and actions was seen as valuable with one participant stating, “I think there’s always a benefit in watching yourself doing something because you don’t see it as you’re doing it” (p. 120). The potential benefits of providing individuals versus groups with feedback of their compliance data has been discussed (Cheng et al., 2011; Smiddy et al., 2019).

The rich and detailed data provided by video recording allows the problem or issue under investigation to be more fully defined and understood. As Grabowski et al. (2018) noted, this could be a critical tool with which to “understand the behaviours that occur” (p. 121). Pickering et al. (2014) viewed video recording as advantageous, suggesting that the technology has the “capability to capture new behavioural insights” (p. 1) that would be otherwise missed, while Jacobs et al. (2010) pointed out that “an understanding of the system’s cause and effect relationships allows one to begin predicting how the system might be improved” (p. 725). Providing support for the contention that in order to solve a problem, one must fully map and understand it, and further that video recording is an ideal first step in the process of developing strategies to change those behaviours, is in line with best practice.

Video-based systems are, by and large, considered simple, requiring only cameras and a recording/storage device as compared to the sensors, zone beacons and tags necessary for the previously described real-time locational systems. The inherent simplicity of VMS may mean that such systems are less expensive than many other electronic monitoring technologies. A number of authors argue that the cost of video technology is rapidly decreasing and that videos “no longer require, sophisticated equipment to make” (Hu et al., 2012) supporting the idea that VMS represents a relatively inexpensive modality. Although it must be noted that, while many authors fail to provide full costings of their systems, this is not always the case. Hoang et al. (2018), for example, described their cameras which featured motion detector activated recording as well as a display screen to play an instructional video as costing US$2,119 per unit. A recent enquiry has demonstrated that a simple “off the shelf” system comprising 8 motion detector, infra-red cameras and a hard drive can be purchased for under $800 (Quotation via email, 2019). It is acknowledged, however, that some video-based systems are quite expensive and examples of this would be the works of Armellino et al. (2012), Palmore and Henderson (2012) and Overdyk et al. (2016). Although full costings are not provided, the systems described are estimated at between $50,000 and $200,000 to install and in the latter instance also to maintain for the first year of operation. However, these technologies do represent the most elaborate end of the video-based technology systems, with large numbers of cameras and the inclusion of real-time compliance feedback, which Overdyk et al. (2016) reports as costing US$40 per theatre per day.

Proponents of VMS will argue the worth of even the most expensive systems on the basis of cost savings achieved through the use of such technologies. In terms of hand hygiene monitoring, it is contended by some authors that, although there are costs associated with VMS at the simpler end of the technology scale, these are minimal and reducing. Furthermore, there are potential savings in the use of such technology, including, as previously noted, the reduction of auditor time associated with the collection of data (Pickering et al., 2014). Potential increased validity and reliability of the data as compared to that collected by direct observation may represent a saving in terms of enhanced cost-effectivity. Video-based systems may be able to collect more accurate data in less time as compared to direct observational auditing representing better 'value for money' (Azim et al., 2016; Kwok et al., 2016; Stackelroth & Shaban, 2011).The collection of more accurate data also has the potential to allow the more precise identification and subsequent targeting of specific areas and causes of noncompliance, this in turn can effect real change in HCW behaviour through more focused and individualised interventions. The ultimate aim being a reduction in microbial transmission and as a consequence, HAIs, representing a further cost saving to organisations has been discussed (Sahud et al., 2012). A review by Conway (2016) does note that, as yet, "no cost-effectiveness study of an electronic HH (sic) monitoring system has been published" (p. 8). However, it is unclear as to what measure the author is referring in this instance. A system may be deemed cost-effective or not on a variety of levels ranging from or variously including the ability to collect data, drive compliance or reduce HAIs (Conway, 2016; McLaws & Kwok, 2018).

Perhaps the most significant benefit of VMS as compared to other forms of electronic monitoring systems is the potential to capture data according to the 5 Moments framework (Boyce, 2017a; Diller et al., 2014; Dufour et al., 2017; Haac et al., 2017; Sanchez-Carrillo et al., 2016). In particular, this is demonstrated in the works of Diller et al. (2014), Sanchez-Carrillo et al. (2016) and Haac et al. (2017). These studies all described systems with the technical capacity to record footage which allowed hand hygiene compliance to be measured against the WHO 5 Moments criteria. As such, this contrast with the majority of studies that utilise electronic monitoring systems and rely on alternative compliance metrics such as entry/exit. The work of Armellino et al. (2012) being a prime exemplar of this limitation has been discussed.

Video Monitoring Systems and the Hawthorne Effect

The question of whether video-based systems minimise or enhance the Hawthorne Effect is the subject of debate and would appear to be dependent on the structure, function, operation and overall aim of the individual system. Some authors cite the benefits of video-based systems as the ability to reduce, minimise, overcome or even eliminate the Hawthorne Effect (Daniels, 2012; D. J.

Gould et al., 2017; Haas & Larson, 2007). Boyce (2017a) notes that data collected by video surveillance is subject to a "lack of typical Hawthorne Effect" (p. 531) supporting the idea that the Hawthorne Effect is reduced or modified rather than totally eliminated by VMS. Other authors described systems which appeared designed to purposely leverage the Hawthorne Effect through their functionality (Armellino et al., 2012; Pedersen et al., 2017; Rex et al., 2010). Weinger et al. (2004a) noted that video recording is "largely unobtrusive and, if done properly, there is little risk of … inducing a Hawthorne Effect" (p. 142). Brotfain et al. (2017) demonstrated the differences in the Hawthorne Effect with auditing via video as compared to direct observations using a live stream from a previously installed CCTV. Although the yield of Moments was limited due to camera placement (intended for patient visualisation rather than hand hygiene practice capture) and thus "black spots", the study did demonstrate a significantly lower hand hygiene compliance via video auditing and attributed a delta of 10% as being explicable by the Hawthorne Effect.

Some studies have in fact been able to claim total elimination of the Hawthorne Effect. The works by Nishimura et al. (1999) and Rex et al. (2010) involved periods of filming of which the staff were totally unaware. Nishimura et al. (1999), for example, described the use of hidden cameras which were secretly installed to record hand washing practices at the sinks of a NICU. The presence of the system was only revealed when the results of the study were presented to the staff of the unit. Similarly, Rex et al. (2010) secretly recorded a series of colonoscopies in order to establish baseline practice prior to commencing their investigation. Other researchers have utilised footage previously collected for other purposes and then assessed it for additional compliance metrics. Examples would be the repurposing of resuscitation footage, originally captured for quality and education purposes relating to Emergency Department practices by Brooks et al. (1999) and Haac et al. (2017). HCWs knew that they were being recorded, owing to this being a routine practice for "the past 20 years" (Haac et al., 2017, p. 3). However, staff would not have been aware that their hand hygiene compliance was going to be assessed from this footage. Secret and repurposed recording and the subsequent compliance calculation would therefore be deemed to be able to measure compliance behaviour which was a reflection of true practice unaffected by the Hawthorne Effect. Recording patients and HCWs without their consent may however present ethical, moral and/or legal issues. It may also, when ultimately revealed, be seen as a breach of trust between clinicians, managers and researchers, as well as evoking issues of 'Big Brother is watching' as has been discussed.

Other studies have described the practice of overtly installing cameras but describing their function as collecting data for purposes other than that which is strictly correct or accurate. For example, J. Brown et al. (1996) installed a camera in a NICU in Colorado (USA) and informed staff

that the “ostensible purpose... [was the] recording of traffic patterns for optimal design of a new NICU” (p. 908). The rationale for this deception was that the Hawthorne Effect would therefore not impact upon the practice of HCWs. No information is provided as to the HCW responses to such subterfuge. Another approach to video systems and the Hawthorne Effect has been to install cameras weeks or months prior to a study of which staff are aware. The early installation being seen as a chance for participants to become habituated to the presence of the system. Subsequently, several authors report how the system commenced recording without formal announcement prior to the notional start date of the study. Armellino et al. (2012), for example, described a 12-week period prior to “official auditing” (p. 3) where data was recorded to validate the system and an additional 4 weeks during which data was collected without formal announcement. During these 16 weeks no information or feedback on hand hygiene compliance was provided to staff even though system defined compliance at this time was recorded at less than 10%. As such, it is suggested that practice during this period was either not, or only minimally effected by a VMS induced Hawthorne Effect. Similarly, Sanchez-Carrillo et al. (2016) installed cameras in an open plan Haemodialysis unit with the knowledge of the staff. The cameras were in place but not in use for two months, again presumably to habituate the HCWs to their presence. Recording was then undertaken for a four-week period “without the staff’s [sic] knowledge of being video monitored” (p. 869). Compliance during this period averaged 21% and again was presumed to be free or at the least largely free from any Hawthorne Effect. Once recording formally commenced and staff were provided with feedback of their results compliance increased to 36% and subsequently to 50% following an educational intervention. It is unclear, however, whether the commencement of the recording and the provision of feedback occurred simultaneously or were separate events. Thus, it is not possible to determine if the increase in compliance was due to an awareness of being practice being recorded or a combination of this awareness as well as the impact of having received feedback.

By and large, it would appear that participants very quickly become used to discreet cameras recording their practice in the healthcare environment and consequently it is argued that the Hawthorne Effect wanes or is overcome (D. J. Gould et al., 2017; Grabowski et al., 2018). Much cited evidence for this habituation comes from the study of food preparation in domestic kitchens undertaken by Jay et al. (1999). Despite the knowledge that cameras were present, subjects were recorded as engaging in behaviours and practices not only in contrast to those which they self-reported, but also that they were unlikely to have performed in the presence of a physical auditor or observer. This included the preparation of food on surfaces contaminated by footwear, hair brushes or domestic pets, consumption of food left unrefrigerated for long periods or which had been partly ingested by animals, wiping of surfaces with dishcloths which had previously been trodden upon,

fingering the nasal area and then proceeding directly to food preparation, as well as infrequent hand washing and poor technique. Similarly, Hu et al. (2012) noted that the audio dialogue and associated video footage recorded of part of their study indicated that "participants forgot about the recording in the course of the case" (p. 9), thus while there may have been a degree of Hawthorne Effect due to the recording of practice it was deemed to be significantly less than would have been elicited by the "live presence" (p. 9) of an observer who would have served as an ongoing reminder of observation of practice. The study by Clack et al. (2017) involved staff wearing head-mounted cameras for relatively short periods (average 70 minutes) to investigate the hand transmission of microorganisms. It is interesting to note that even with such a relatively short period of being monitored by a relatively overt technology, participants reported that their "awareness of wearing a camera and their activity being registered waned quickly" (p. 7). Similarly, in 2020, Diefenbacher, Sarrenrath et al. published the results of a study where staff wore body cameras to audit their hand hygiene compliance during simulation exercises. They reported that only one-quarter of participants felt "disturbed" and only one-third felt "watched" during the use of cameras.

Therefore, while it is clear that discreet VMS have the capacity to collect data unaffected, or at the least minimally affected, by the Hawthorne Effect, there are a number of studies illustrating the opposite. That is, the researchers have deliberately leveraged the Hawthorne Effect associated with video recording of practice to achieve a desired behaviour change. A prime example of this is the study by Rex et al. (2010). After the period of secretly filming colonoscopies to establish baseline behaviours, all participants were informed that their procedures would subsequently be recorded and reviewed for compliance with various established parameters. In addition, practitioners were reminded at the beginning of each procedure of the recording and review process, hence overtly raising the awareness of the presence of "observers", in this instance via the video camera. This study saw a statistically significant increase in mean inspection time (49%) and inspection technique (31%) once the recording of practice commenced. This improvement was deemed to be due to the awareness of the recording as no feedback was given until the completion of the study when the data was analysed. In a similar vein, the recording of hand hygiene practice by Diller et al. (2014) involved placement of signage in prominent places around the ward to remind staff that recording was taking place which may have impacted compliance via the Hawthorne Effect. The studies by Armellino et. al. in 2012 and 2013 appear to have leveraged the Hawthorne Effect in combination with the response to the provision of feedback to drive compliance. Staff could not help but be aware of their practice being recorded as feedback was continuously provided in near real-time via display screens. Furthermore, anytime that compliance slumps were detected, interventions were undertaken to re-focus attention onto the monitoring process. Once again, it is unclear how much of

the behaviour change was driven by the awareness of the presence of cameras and how much related to the feedback of practice. The system described by Pedersen et al. (2017) also involved the use of cameras and remote auditing and real-time feedback and similarly it is not possible to distinguish how much of the practice change is attributable to a video-mediated Hawthorne Effect and how much arose due to the real-time feedback. With this system however, HCWs were required to actually interact with those monitoring via the cameras. For example, by holding up variously coloured cards to demonstrate completion of an activity and therefore compliance. Such requirements would only serve to highlight and remind staff that their practice was being observed.

It is therefore possible to conclude that the use of a VMS has the potential to affect the collected data via the Hawthorne Effect to a varying degree and further that the magnitude of this effect is dependent on the system itself. A covert recording process will clearly have no impact while discreet, unobtrusive recording systems of longer duration will have only a minor effect. Conversely, those which are overt and/or require practice changes or some form or reminder or interaction between the system and the HCW have the capacity, and indeed often the intent, to drive behaviour change, at least in part due to the mechanism of the Hawthorne Effect. Thus, it will be important to consider the purpose of any VMS. If, for example, the aim is not only to measure compliance but to drive it, then systems which incorporate reminders and/or immediate feedback will be required. If the aim of the system is to capture an accurate reflection of true HCW behaviour, unaffected by observation bias, then a discreet or covert system is more useful.

Disadvantages of Video Monitoring Systems

As with other forms of electronic surveillance for compliance monitoring, video-based systems are not without their problems and drawbacks. Common to any data collection methodology, it is important to recognise and account for any barriers associated with, or limitations of, the system being considered. Although, as Dufour et al. (2017) notes, video-based systems are the only form of electronic monitoring systems currently capable of measuring hand hygiene compliance according to the WHO 5 Moments criteria, it does not automatically follow that all video-based systems have this capacity. As previously noted, the ability to capture all 5 Moments is highly dependent on system design, particularly camera location and density. Placement of cameras within patient rooms (Diller et al., 2014) or within open plan settings (J. Brown et al., 1996; Sanchez-Carrillo et al., 2016) will generally capture the majority of hand hygiene opportunities. However, a number of studies (Armellino et al., 2012; Armellino et al., 2013) have used what Fries et al. (2012) describes as the “practical proxy measures for hand hygiene opportunities” (p. 690) of room entry and exit rather than the WHO 5 Moments. Entry and exit systems utilise cameras at doorways

and/or sinks to capture hand hygiene performance. As a consequence of such placement, a significant proportion of HCW-patient interaction will not be assessed for hand hygiene compliance. Furthermore, the use of the entry-exit measure of compliance fails to locate the performance of hand hygiene within the clinical context of care, as performing hand hygiene in response to entering or leaving a room may not actually conform to an actual indication for hand hygiene. Hence, placement which fails to capture the entire care episode will not allow for an accurate determination of whether a given hand hygiene episode constitutes compliance. Given that the ability to capture all 5 Moments is cited as a major advantage of video-based systems, it is important to consider whether this is possible with an individual technology. The failure of this capacity could well be considered a significant disadvantage of the modality.

The justification for not placing cameras such that the entire care episode is episode is captured centres around concerns relating to patient privacy. Authors speak of “inherent tensions” (Palmore & Henderson, 2012, p. 9), “special challenges” (Boyce, 2017a, p. 532), “serious issues” (Ward et al., 2014, p. 475) and of the matter being “fraught with problems” (D. J. Gould et al., 2011, p. 291) when discussing patient privacy in relation to what Momen and Fernie (2010) describe as “vision based systems” (p. 394). Diefenbacher et al. (2020) described patient privacy as the “most challenging aspect” (p. 497) of a video-based approach. Various solutions to these issues have been suggested including the aforementioned entry-exit proxy metrics utilised by Armellino et al. (2013) to “protect patient privacy” (p. 2). Other strategies have included aligning cameras such that patient identification was avoided or using low resolution footage (Xiao et al., 2007). However, such approaches may mean that the capacity to distinguish all 5 Moments is lost, hence reducing the utility of such technology if measuring compliance according to this criterion is the goal.

Despite the issue of patient privacy being raised quite frequently as a problem associated with video-based systems, the question as to whether it is a genuine concern for patients is less clear. As previously noted, Clack et al. (2017) found that patient objections to filming were quite rare once information was provided. A survey conducted by Raghavendra and Rex (2010) found that 81% of patients undergoing a colonoscopy were interested in having their procedure recorded and 63% were prepared to pay for it. This would suggest that patient concerns about video-based compliance monitoring may not be a barrier to, and hence disadvantage of, such systems. Diefenbacher et al. (2020) speculate “overall privacy issues might be of low concern to both HCW and patients, at least when they are properly informed” (p. 501). However, it is also clear that the area requires further investigation and is certainly a factor that must be allowed for when planning the implementation of such technologies.

Obtaining patient consent is seen as one solution to concerns about patient privacy, although the need for such consent may vary based on the system design, as well as local legislative requirements. Haac et al. (2017), for example, does not mention the need for consent when recording resuscitations in their Emergency Department. Xiao et al. (2007) described how the requirement for consent was waived due to camera angles making patient identification unlikely, while Jacobs et al. (2010) noted that standard procedural consent was sufficient to cover video recording as the practice had been deemed "standard operating procedure" (p. 725) at that facility. In a similar vein, Hu et al. (2012) described an "opt out" rather than a consent driven approach where consent was passively assumed unless a participant actively elected to decline. Weinger et al. (2004a) suggest the appropriateness of a "waiver of informed consent" (p. 142) as applying to such works on the basis of status as a quality improvement project. Blank-Reid and Kaplan (1996), in an American setting and relating to resuscitations recorded in the Emergency Department, "have assumed the position that consent need not be obtained as the video recording of resuscitations fall under the Peer Review/Peer Protection Act" (p. 12). In a study undertaken in Australia in 2001-2002, medicolegal advice regarding staff and patient privacy was that "as an auditing tool, the project was exempt from existing privacy legislation"(Oakley, Stocker, Staubli, & Young, 2006). Diller et al. (2014), on the other hand, obtained formal written consent from all patients recorded in their validation study. Twenty-six patients agreed to participate although no information was provided as to the refusal rate. Patients also had the ability to obscure the cameras at any time they desired. A review of the Australian Privacy Principles as well as the Privacy Act (Australian Parliament, 2014; Commonwealth, 1988) does not provide a concrete answer. A sub-clause suggests that the collection of data relevant to or necessary for research, the compilation of statistics, public health or public safety may constitute a "permitted health situation" (Australian Privacy Principles, section 16B) and therefore may be exempt from normal consent requirements. The requirement for consent may therefore be dependent on the scope and design of the system, existing implemented institutional practice, policies or procedures surrounding consent and video recording as well as local consent requirements, privacy principles, rules or legislation. It is clearly an issue that would require clarification and possibly even legislative mandate to resolve. As such, it may therefore represent a complicating factor and potential disadvantage of video-based compliance monitoring systems.

Another commonly cited concern relating to recording of patient care is what is described as the "risk of legal discovery" (Overdyk et al., 2016, p. 952). Weinger et al. (2004a) notes that in the setting of an adverse event, video footage could represent "damming evidence" (p. 143) in a malpractice claim. While recommending research into the medicolegal implications of video recording, both Weinger et al. (2004a) and Makary (2013) suggest that by declaring "a priori" that

video recordings were for quality improvement purposes they would be rendered “not discoverable by plaintiff’s attorneys” (Makary, 2013, p. 1592). Similarly, van Dalen, Legemaate, Schlack, Legemate, and Schijven (2019) noted that footage collected for quality improvement purposes does not form a part of the patient record, but then go on to add that where precisely this line is drawn remains unclear in many settings. Despite the fears regarding medicolegal risk, evidence would indicate that this is an uncommon occurrence and that, more often than not, the video footage provided supportive evidence of good practice in favour of HCWs (Le Bris et al., 2020; O'Donnell, Kamlin, Davis, & Morley, 2008; van Dalen et al., 2019). What is clear however, is that the status of such footage and any consent or other legal issues surrounding its collection, storage and disposal would require clarification at a local jurisdictional level.

HCW concerns regarding privacy have the potential to be a significant barrier to successful implementation of a VMS and hence may represent a major disadvantage of such technology. As previously discussed, concerns of a ‘Big Brother is Watching’ nature are associated with electronic monitoring systems in general (Palmore & Henderson, 2012). It is possible, however, that this issue may potentially be heightened in relation to video-based systems due to the potential for enhanced individual identification via recorded footage. While Sahud et al. (2012) refers to concerns about “infringement of personal privacy” (p. 271) in relation to a tag-based system, it is interesting to note that authors such as Armellino et al. (2012), Diller et al. (2014) and Sanchez-Carrillo et al. (2016) who utilised video-based systems did not describe problems of this nature. Although this does not preclude participants having expressed such concerns which were not subsequently disclosed in the study reports. In response to such apprehensions, Armellino et al. (2012) and Palmore and Henderson (2012) take the stance that as hand hygiene compliance is a condition of employment, and that as employees have signed a contract stating they will comply with institutional policy, they are obligated to have their compliance confirmed, be it by direct human observational or electronic methods. Such a mandate may be insufficient to overcome concerns of staff, who may worry, in particular about the potentially punitive uses of recorded footage. Pedersen et al. (2017) reported working with participants to give them assurances as to the purpose and usage of their system, but being uncertain as to whether this was accepted as “fears and rumours” (p. 160) continued to sweep through the department. Boscart et al. (2008) noted that participants in their study reported that they did not mind being recorded but did express concerns about data confidentiality and security. A number of authors outlined the additional steps required to reassure staff of the supplementary data security measures required or undertaken in relation to the recorded footage, such as password protected, secure, non-network storage, agreed confidentiality and retention/deletion details (Grabowski et al., 2018; Weinger et al., 2004a). In addition, the development and

communication of institutional policies as to how “data would be stored and feedback provided” (Boyce, 2017a, p. 532) was also seen as important. Despite such efforts and safeguards, concerns may persist as to the potentially punitive uses of the data. Bouk et al. (2015) noted that detected noncompliance had the potential to affect salary, bonuses and the potential for promotion. While D. J. Gould et al. (2011) stated that footage could be utilised to provide “watertight evidence of failure to comply” (p. 292) as part of disciplinary action. While the aim of ensuring patient safety via high rates of hand hygiene compliance is laudable, such statements may only serve to provoke concerns of punishment in HCWs. These emotive issues may therefore result in the need for considerable time and effort to gain staff acceptance and trust of video-based surveillance systems if problems such as sabotage and avoidance are to be circumvented (D. J. Gould et al., 2017; R. J. Holden & Karsh, 2010).

Another disadvantage of video-based technologies is, apart from the more elaborate “real time” systems, the inability to provide immediate or even particularly rapid feedback to HCWs regarding their compliance (Dufour et al., 2017). Most systems involve the recording of footage for later review. Indeed, this is seen as a potential advantage in that review can occur at a more convenient time and the capacity to fast forward and review at a higher speed can offer greater efficiency. However, this functionality potentially comes at the cost of the loss of immediacy of feedback. Sanchez-Carrillo et al. (2016) and Hu et al. (2012) would contend that the capability to provide specific one-to-one feedback via the use of individualised recorded footage excerpts outweigh the disadvantages of delay. Participants in the study by Mackrill et al. (2017) concur, reporting a belief that feedback of contextual data was more important than immediacy of feedback. Participants elaborated noting that such meaningful and personalised information was more useful to HCWs to improve their practice. It is argued that it is essential that audit feedback is sufficiently detailed to provide staff with “meaningful instruction regarding how they should change their behaviour to achieve infection prevention goals” (Dawson, 2015, p. 253).

However, while the provision of highly specific feedback has been shown as a valuable and effective way for HCWs to improve their practice and compliance (Sax et al., 2007), it is nonetheless a very time consuming method and one which must be handled with caution and sensitivity. While both Hu et al. (2012) and Sanchez-Carrillo et al. (2016) described the process of using individualised video feedback as a useful and effective method of assisting staff to reflect upon and improve their practice, the authors acknowledged that care needed to be taken so that staff did not feel uncomfortable, judged or singled out in response to the feedback concerning noncompliance (Hu et al., 2012; Sanchez-Carrillo et al., 2016).

While video-based systems may involve a reduction in auditor time for footage review as compared to human auditing in the clinical space, this time requirement is not totally eliminated. Research with complex video and accelerometer-based technologies, incorporating features such as pattern recognition, activity tracking and mapping, statistical learning and predictive algorithms have shown promise. However, as yet, there has been no concrete solution arising from these investigations (Momen & Fernie, 2010; Zhongna et al., 2008). In addition, artificial intelligence and machine learning such as those described in the works of Chan (2022 - prepublication) and Nguyen-Duc (2022) may have potential but are still in the early stages of development. Therefore, unlike other forms of electronic monitoring which require little in the way of human resources to collect compliance data, systems involving video recording may still potentially involve substantial personnel time to review the recorded footage as compared to the imposts of dispenser activation or tag-based systems. While it can clearly be argued that the data provided by VMS is richer and more detailed, the process, as Haas and Larson (2007) "remains resource intensive" (p. 7), although potentially less so than direct observation.

The cost of technology may represent another disadvantage of VMS. Although the cost of cameras and associated data management and storage units have significantly reduced in recent years, substantial outlay may still be required if features such as real time review, a high density of cameras to allow wide scale departmental coverage or large data storage capacity are required (Conway et al., 2014; Overdyk et al., 2016; Pincock et al., 2012). In addition to potential costs associated with the actual installation, the implementation of a VMS may also require disruptions to infrastructure and services further adding to the costs burden to facilities. As such these imposts need to be factored into any consideration of the cost-effectiveness of a VMS.

Video-based systems are often advocated on the basis that they are free from the biases inherent in direct observational auditing or the more overt forms of electronic monitoring systems. As has been discussed, more discreet system designs may mean that the Hawthorne Effect is reduced, however other forms of bias may impact upon the data. Selection bias may be a concern if not all areas of the ward or department are monitored (Diller et al., 2014; Haas & Larson, 2007). Ideally, camera placement and density should ensure that all, if not the majority of, HCW-patient interactions are recorded in order to avoid selection bias, however this is unlikely to be practical or achievable (van de Mortel & Murgo, 2006; Ward et al., 2014). Furthermore, HCWs may be able to engage in avoidance behaviours by relocating care interactions to unmonitored areas (D. J. Gould et al., 2017). This may be particularly problematic in systems which have minimal cameras or rely on repurposed footage. Observer bias may also persist with individual auditors choosing consciously or unconsciously to interpret recorded behaviours in a particular way based on individual perceptions

or beliefs, particularly where there is ambiguity as the recorded footage and the option to replay and review is not taken up (Clack et al., 2017; Hu et al., 2012).

Finally, Latvala et al. (2000) warns of potential ethical issues that may result from VMS, in particular "the possibility of witnessing unethical behaviours that interfere with patient care" (p. 1256). This may include matters not relating to the purpose of the recording, but which may nonetheless compromise patient safety or optimum care. Careful consideration would need to be given as to how such situations would be managed should they arise.

CRITICAL CONSIDERATIONS OF THE LITERATURE FOR THE STUDY

The critical review of the literature has yielded several key findings relating to the potential for, and limitations of, electronic systems for hand hygiene compliance measurement. Many proponents of electronic monitoring systems see such technology as a panacea, the ideal solution to all the problems associated with direct observational auditing and ultimately as the inevitable replacement for the methodology. However, as Pires and Pittet (2017) warn, electronic monitoring systems are "no magic bullet" (p. 465) but do go on to suggest that such technology may have a role as part of a multimodal approach alongside direct observational auditing. It is clear that many can, and indeed do, provide valuable data, often in large quantities. However, there are very few modalities which can monitor compliance according to the WHO 5 Moments criteria, instead utilising proxies or surrogates which may not reflect a relationship between hand hygiene behaviour and microbial transmission. There is also a risk that the definition of hand hygiene compliance could shift to these electronic monitoring systems mediated proxy measures rather than the WHO 5 Moments. This is a concern if it occurs simply because this proxy measure is the output metric which the technology can easily provide as distinct from a form of measurement of a practice which reflects the interruption of pathogen transmission (Korhonen et al., 2015; Pires & Pittet, 2017).

Video-based systems are currently the only modality with technological specifications with the potential to capture and audit hand hygiene practice according to the WHO 5 Moments. As such this technology is also well placed, in the Australian context, to meet the submission requirements for the NHHI. In addition, such approaches could theoretically represent time and financial benefits to healthcare providers. Despite this potential, there are barriers and limitations. Once again, video-based systems, like other forms of electronic monitoring systems, are not the "magic bullet". As has been demonstrated, not all systems have the technological capacity to monitor compliance with all 5 Moments due to design features such as camera placement and/or density (Armellino et al., 2012). There are also barriers to implementation beyond the limitations of the technology itself. These have clearly been identified in the literature review and include factors such as the cost of the

systems and their associated infrastructure. Issues relating to HCW acceptance of the technology, as well as concerns surrounding staff and patient privacy and consent may also provide barriers to successful implementation. The literature has however identified a number of aspects which require further investigation in the development of a video-based approach to hand hygiene auditing.

Study 1 of this doctoral study explored the issues with and benefits or strengths of both direct observation and video-based approaches to hand hygiene, as well as investigated technology-based options for compliance monitoring. Interviews with clinicians and technical and methodological experts informed the development of an overall approach to hand hygiene compliance monitoring which drew on the strengths of both methodologies and included the codification of technical and methodological specifications of the system. Study 2 assessed the efficacy, accuracy, efficiency and cost-effectiveness of VMS via a proof-of-concept trial in simulation, while Study 3 explored the acceptability of the approach for HCWs and patients.

CHAPTER 3: METHODS

This chapter explains the methodology used to conduct the research. The overall design and paradigm are discussed and then the approach used in each of the three studies in terms of participant selection, data collection, ethical implications, participant demographics and analytical methods are outlined in separate sub-sections.

Study Design

The overall design utilised for this study is a pragmatic, exploratory sequential mixed-methods approach with an embedded experimental intervention. The pragmatic paradigm is an ideal standpoint to explore the issues inherent in this study. Pragmatic approaches are those which focus on the identification of and solution to real world problems. In this instance the real-world problem or problems associated with the current gold standard hand hygiene compliance monitoring methodology – direct observation – as well as the variously proposed solutions. Pragmatism is practical, focusing on the context, what works and on real world problems and their solutions (Cherryholmes, 1994; Creswell & Creswell, 2018). Those working from a pragmatist paradigm believe that the research question is what should guide and direct the inquiry (Polit & Beck, 2008) and further as Cherryholmes (1992) notes, pragmatic research is also "driven by anticipated consequences" (p.13) and is not limited by a single method or any one philosophy in pursuit of answers to the research question. Thus, researchers are free to "choose methods, techniques and procedures that best suit their needs and purposes" (Creswell & Creswell, 2018, p. 10). This means that the pragmatic world view and a mixed-methods research design are well suited. Polit and Beck (2008) note that pragmatism is in fact the paradigm most often associated with a mixed-methods design. While Holloway and Wheeler suggest that mixed-methods research does in fact have its "roots in pragmatism" (p.270) arising as it does from the works of philosophers such as Charles Peirce, William Jones and John Dewey in the early 20th Century (Cherryholmes, 1992, 1994; Holloway & Wheeler, 2010). Thus, this design is the ideal one to investigate, better understand, implement and ultimately evaluate a proposed solution. In this instance, the utility of a video-based approach as a way to ameliorate the identified problems with the current direct observational data collection techniques. Holloway and Wheeler (2010) contend that mixed-methods research is ideal for the translation and application of basic research and scientific discoveries into the reality of clinical practice in healthcare.

Mixed-methods approaches combine or 'mix' of both quantitative and qualitative methodologies to answer a research question. Whereas quantitative designs focus on concrete

variables, measurement and evaluation of phenomena they may fall short in an explanation of why certain factors my effect a result or outcome (Creswell & Creswell, 2018; Forman, Creswell, Damschroder, Kowalski, & Krein, 2008; Holloway & Wheeler, 2010). For example, Forman et al. (2008) notes that although quantitative studies have proved advantageous to progress in infection prevention and control, they are often unable to provide insight into, or explanation of, the rationale for behaviours, such as the adherence to infection prevention practices nor to "identify the underlying mechanisms through which they do so" (p. 764). Qualitative studies, on the other hand, are well suited for the explanation of the motivation for behaviours and for viewing a research problem and its solution from the perspective of participants or end users (Creswell & Creswell, 2018; Holloway & Wheeler, 2010). Creswell and Creswell (2018) describes qualitative approaches as being holistic and discovery orientated with the goal of understanding the phenomena under study rather than measuring it.

Proponents of mixed-methods research argue therefore that both quantitative and qualitative designs have limitations and that by combining the two methodologies a stronger, fuller and deeper understanding of the research question may be gained (Creswell & Creswell, 2018; Holloway & Wheeler, 2010). Mixed methods may enhance or extend a study by not only measuring and evaluating the phenomena being explored, but also by understanding the motivations, rationales, barriers to and enablers for, its use or misuse (Creswell & Creswell, 2018; Polit & Beck, 2008). Nowell, Norris, White, and Moules (2017) notes that qualitative inquiry is "intended to generate knowledge grounded in human experience" (p. 1). In the context of this doctoral study, it is not only important to evaluate the feasibility and time efficiency of the proposed approach but also to understand HCW and patient concerns about and responses to it. While quantitative methodology measures the success or otherwise of the system, qualitative elements provide insight into how and why the intervention did or did not work. As Forman et al. (2008) notes, "addressing these issues is complex because they involve human interactions in complex healthcare environments" (p.764), hence it is argued that a more complex research design is warranted.

More specifically, as noted, this doctoral study uses a mixed exploratory sequential design with an embedded experimental intervention (Table 2). This incorporates an extensive literature review along with qualitative interviews. Analysis and development of interview themes allowed for the identification of the issues with and strengths of various methods to auditing and in turn allowed for the determination of the technical and methodological specifications required for a video-based approach. This was followed by the experimental intervention – that is, the proof-of-concept trial in simulation of the approach and subsequent quantitative evaluation of feasibility and time efficiency. And finally, a qualitative investigation into the acceptability of the system to end users.

Table 2. Study outline with phases, research questions and data collection methodologies.

Study	Research Question	Data Collection
Study 1	What might be the technical and methodological specifications required for a video-based approach to hand hygiene auditing?	Literature review
		Interviews with content experts
Study 2	What is the feasibility and time efficiency of a video-based approach to hand hygiene auditing?	Proof-of-concept trial in simulation
Study 3	What is the acceptability of video-based surveillance for hand hygiene auditing for HCWs and patients?	Post proof-of-concept trial group interviews
		Online surveys
		Interviews with key HCWs and patient informants

STUDY 1 – TECHNICAL AND METHODOLOGICAL SPECIFICATIONS

The aim of Study 1 was to determine what technical and methodological specifications might be required for a video-based approach to hand hygiene auditing according to the 5 Moments criteria. By identifying issues with and benefits or strengths of both direct observation and VMS, and then combining these learnings with those of the literature review and the outcomes of discussions with technical and methodological experts, the specifications of a video-based approach was able to be developed. This ultimately informed the development of the VMS approaches which were subsequently trialled in Study 2.

Study Design

In-depth semi-structured interviews within a pragmatic naturalistic theoretical framework were utilised for this study.

Data Collection

In exploring the research problem and taking the first step in answering the above question, an extensive literature search was conducted as described in Chapter 2. This review provided the background and rationale for the study outlined in Chapter 1, as well as a discussion of the previously proposed solutions to the identified problems with direct observation, these being in the form of various EMS for hand hygiene compliance. The review in Chapter 2 highlighted the limitations of these approaches and provided the warrant for further research. A further aspect of the literature review focused on the identification of video technology and its application to healthcare which in turn had potential for use in the hand hygiene compliance monitoring context.

The second facet of data collection for Study 1 involved interviews with clinical experts in order to further inform the development of the proposed approach. Participant selection was

purposeful as is typical in qualitative research. Participants were invited to take part on the basis of their ability to help the investigator to understand the problem, to provide rich information and to be what Forman et al. (2008) describes as “analytically useful sources for answering the research problem” (p.766). Clinical participants for interview were sought in 4 classifications of expertise: content experts (CE), managers of data (MOD), collectors of data (COD) and recipients of data (ROD).

Informants were able to provide rich information as a result of their backgrounds, knowledge and experience. In addition, being from such a diverse range of organisational, geographical and practice settings allowed for triangulation of data sources and hence, enhanced credibility in the data (Morse, 2015; Shenton, 2004).

Interviews with the clinical staff (CE, MOD, COD, ROD) were conducted either in person, online (via Zoom™) or by telephone depending on the participants geographical location and personal preferences. Where possible, face-to-face interviews, either in person or via Zoom™, were preferred as this allowed visual body language cues to be noted and enhanced the rapport development between researcher and participant. Interviews were semi-structured, utilising a question stem or topic guide designed to elicit information about the potential video-based approach to hand hygiene auditing. The topic guide [APPENDIX E] contained a list of areas to be covered but was not prescriptive with sequencing being altered and adapted to the individual context. The benefit of the guide was that it kept the interviews relatively standardised and enabled the researcher to collect similar data from each participant. However, this still allowed the participants to answer in their own words (Holloway & Wheeler, 2010; Morse, 2015; Polit & Beck, 2008). The guide was also modified and added to as the interviews progressed as a concurrent analysis suggested new or expanded areas to explore with subsequent participants. Forman et al. (2008) notes that this is a common occurrence in qualitative research in that data collection should be an iterative process of discovery where “data collection and analysis occur concurrently” (p. 766). This preliminary analysis can, should and indeed did guide further data collection (Sandelowski, 1995).

Interviewing was selected as a data collection method as it is an ideal method to explore the views, beliefs, thoughts and feelings of participants in relation to the phenomena under study (Holloway & Wheeler, 2010). The use of a semi-structured approach allowed participants to talk freely about hand hygiene auditing and specifically explore the question of a video-based approach incorporating vision-based surveillance technology. They were able to do so in the own words and in as much or as little detail as they chose. The use of open-ended questions and prompts encouraged discussion and expansion of ideas and allowed rich data to emerge.

Most interviews were conducted one-to-one with the exception of two instances where colleagues elected to be interviewed jointly. It was unclear if this had an inhibitory effect on participant's willingness to voice honest opinions. In one instance there was a noted power imbalance between participants and it appeared that the junior participant was reluctant to share their opinions. In the second joint interview no such inequity existed, and participants were notably frank and open, often prompting each other to respond and expanding each other's points. Analysis of the data which emerged from these interviews did not identify any unique themes however, suggesting that while participants may have been more or less frank as a result of undertaking an interview with a colleague the substance of their responses remained consistent. Inhibition of responses is a factor that must be considered a potential drawback of collecting data via interview. The interview effect (Holloway & Wheeler, 2010) is deemed to occur when participants react to the interviewer (or in the case of joint interview, each other) and modify their responses in order to be perceived more positively or favourably by others, particularly the interviewer or those in a power relationship. This may take the form of agreement with what is perceived to be the researchers views or beliefs (Holloway & Wheeler, 2010; Polit & Beck, 2008). Hence, care was taken to mitigate this propensity and to ensure that participants felt safe to disagree with, criticise and/or illuminate problems with or barriers to a video-based approach to hand hygiene auditing. Participants were encouraged to feel free to express honest feelings regarding the subject matter, it being made clear that there were no "right answers" and that all idea and opinions were both valid and desired. Assurances regarding confidentiality and anonymity were not only given but seemed to be accepted by the majority of participants who seemed sufficiently comfortable to speak openly and frankly. The use of tactics to promote honesty in informants is essential in establishing credibility in qualitative research (Shenton, 2004).

In total, 25 interviews were conducted with 27 clinical staff between June and October 2019. Interviews lasted between 20 and 50 minutes and were audio recorded with the full awareness and consent of all participants. Interviews were transcribed verbatim by the investigator (KMcK) and then checked for accuracy. The use of specialised transcription equipment (AltoEdge USB Foot Pedal) allowed for simple and exact manipulation of the audio recording and enhanced the ease and accuracy of the transcription as well as the verification process. Although this latter step was a time-consuming process which involved repeated listening and re-listening to the audio recording and comparing what was heard to the written transcript to ensure precision it was beneficial in assisting with immersion in, and prolonged engagement with, the data and as such is another strategy for ensuring credibility in qualitative research (Holloway & Wheeler, 2010; Shenton, 2004). V. Braun and Clarke (2006) recommend transcription by the researcher as an excellent way to become

familiar with the data, describing it as an “interpretive act” and an ideal way to inform the early stages of analysis. Bird (2016) goes so far as to describe the process of researcher transcription as a key phase in the process of thematic analysis. Sequential transcription also supported the iterative nature of the approach allowing the researcher to move back and forth from data collection to analysis. Consequently, this allowed any emergent themes or concepts worthy of further investigation to be addressed in subsequent interviews. Transcribed interviews were returned to participants for member checking and to allow, following reflection, for the rectification of errors and the clarification of any confusion. In addition, a second form of member checking was employed during the process of data collection. Ideas generated in initial interviews were raised with subsequent participants. This allowed these ideas to be confirmed or refuted as a form of triangulation with replication indicating the clarification of normative patterns and hence strengthening the reliability of the data. Members of the supervisory team regularly reviewed progress and provided guidance and advice as required.

In addition to interviews with content experts, the input of technical and methodological experts was also sought although this was in the form of repeated discussions via telephone and online platforms rather than formal interviews. At times there were repeated contacts to clarify thoughts and ideas or to explore themes and ideas which emerged from analysis of clinician interviews. Discussions were recorded and transcribed, and emails retained as an aide memoire.

Ethical Considerations

Ethics approval for Study 1 was granted by the Human Research Ethics Committee (HREC) of Sydney University [APPENDIX F]. This phase of the study was considered low risk. This approval was then submitted to the HREC of the investigator’s (KMcK) healthcare network where additional approval was granted in the form of an approval to recruit endorsed by the HREC and the Chief Nursing Officer [APPENDIX G]. The study adhered to the National Statement on Ethical Conduct in Human Research 2007 (2018 update). There were no variations to the approvals as granted, no participants withdrew and at the time of writing no complaints had been received. All participants were provided with a participant information statement [APPENDIX H] and signed a participant consent form [APPENDIX I]. This information included contact information for all members of the research team, as well as for the authorising HREC.

Care was taken when transcribing the interviews to avoid identification of participants. Sequential codes were used for each category of clinical staff and only very general demographic information was retained. Audio recordings were deleted once transcription was completed and verified. Anonymised electronic transcripts were stored in a non-networked, password-protected

drive with coded identifiers stored separately. Any data containing identifiable information (e.g., non-de-identified audio or video recordings) was stored in the Remote Data Store (RDS) maintained by the University of Sydney as per Research and Data Management 2015. Only the researchers had access to these files and all data will be retained for a period of five years after which it will be permanently destroyed.

The possibility of participants becoming emotionally distressed during interview discussions of hand hygiene compliance auditing was considered to be of low likelihood, however, arrangements were made to the potential for referral to the Employee Assistance Program or appropriate counselling services should the need arise.

Data Analysis

The data from the clinician interviews underwent thematic and content analysis (Cavanagh, 1997; D. F. Duncan, 2013). This form of analysis is a commonly used method in nursing and healthcare research (Elo & Kyngas, 2008) and further is seen as a favourable method, being both content selective and applicable to many different research designs.

D. F. Duncan (2013) describes content analysis it as being at the “crossroads of qualitative and quantitative methods” (p.27), while Elo and Kyngas (2008) sees it as a way of “systematically and objectively describing and quantifying phenomena” (p. 108). A central concept of content analysis is the distillation of the words of participants into content or theme-related categories with the purpose of quantifying the frequency with which these ideas appear in the sample (Cavanagh, 1997; D. F. Duncan, 2013; Elo & Kyngas, 2008). However, content analysis is more than just a counting or tallying process, rather it is concerned with understanding meanings, intentions, consequences and contexts making the analytic approach a good fit with the pragmatic paradigm (Cavanagh, 1997; D. F. Duncan, 2013). From the quantitative perspective the focus was on what themes and concepts were identified and how often they arose, whereas looking through the qualitative lens questions such as why and how were asked.

Thematic analysis is a flexible approach to analysing, organising and describing large qualitative data sets and is the ideal method for generating knowledge from human experiences, particularly when examining the perspectives from the viewpoint of a range of different participants (Nowell et al., 2017). Described an analytical method rather than a theoretical framework, thematic analysis is often criticised due to an apparent lack of agreement as to what it actually is and how it should be undertaken. However, many see thematic analysis as a useful foundational method of qualitative analysis which can provide a rich and detailed account of the data (V. Braun & Clarke, 2006). Furthermore, the approach not only allows data drawn from a wide variety of sources to be

organised and described, but also permits both the reflection upon and unpicking of reality (V. Braun & Clarke, 2006; Nowell et al., 2017). The end result, as has been noted, is the generation of knowledge from human experience which is achieved via the recognition of repeated patterns or themes within the data.

What thematic analysis is not however, is a theoretical framework. It is important, therefore, to ensure that, as a method, it is located within an appropriate epistemology. In keeping with the pragmatic paradigm, the analysis was conducted from an essentialist approach in that the assumption was held that meaning and experience may be reflected upon and expressed via language (V. Braun & Clarke, 2006).

Although V. Braun and Clarke (2006) caution against falling into the trap of confusing interview or focus group questions with themes within the data, such questions can and indeed in this instance did, provide the initial organising framework (Sandelowski, 1995). This process also aligns with what Hsieh and Shannon (2005) describe as directed content analysis. Hence, the data was roughly segmented according to the broader questions and explored for themes within these dispersions. The use of a deductive approach framed by the interview question stem and informed by the literature meant that it was expected that the themes would inform, extend, validate or alternatively refute existing knowledge (V. Braun & Clarke, 2006; Elo & Kyngas, 2008; Holloway & Wheeler, 2010). A deductive approach to analysis is ideal when the aim is to build on previous knowledge and/or test theory, particularly when adapting existing data to a new context as was the case with this work (Elo & Kyngas, 2008). Although ideas had been anticipated from the literature, care was taken not to limit the focus of the analysis to the expected concepts but to allow ideas to emerge from the data during the immersion and coding process on account of this (V. Braun & Clarke, 2006; Elo & Kyngas, 2008; Holloway & Wheeler, 2010).

At a practical level, the process of analysis was informed by the approaches of V. Braun and Clarke (2006), Boyatzis (1998) and Sandelowski (1995). The six phases of analysis approach described by V. Braun and Clarke (2006) was the overarching framework for the data analysis in Study 1 and was also subsequently used to identify the themes from the group and individual interviews in study 3. The first stage of this process involved prolonged engagement with and immersion in the data which, as has been noted, aids credibility of the findings as well as allowing the researcher to become highly familiar with the data. To this end the researcher (KMcK) transcribed all interviews verbatim, checked the transcripts for accuracy against the recordings and then actively read and re-read the transcripts. During the later stages of this phase there was a morphing to the second phase

of analysis in that the initial coding commenced. This involved notations in the transcripts when repetition and patterns were identified as familiarity with the data occurred.

More formally, the second phase of the analysis involved the generation of initial codes. A semantic lens was used to identify themes within the meaning of what the participants had said, moving from description to interpretation of patterns or repetitions of ideas in the data relating to the research question. This approach was driven, but not limited by, ideas from the literature. Coding involved note writing and the use of highlighting to link common ideas. Extracts from the transcripts were then collated according to these codes using an Excel spreadsheet. This was not a strictly linear process with analysis of initial interviews occurring concurrently with ongoing data collection and the preliminary analysis of those interviews suggesting new questioning routes as well as allowing member checks between participants (Morse, 2015; Nowell et al., 2017).

Once the data was coded, the focus broadened to search for themes. This was an analytic process involving the use of diagramming, as referred to as a visual representation or a mind or concept map (Boyatzis, 1998; V. Braun & Clarke, 2006; Morse, 2015; Sandelowski, 1995). The process of diagramming assisted in the identification of categories and patterns within the data and, with continued work, meant that initially quite broad categories could be combined and condensed to represent conceptual units of meaning which were linked by the same phenomena or idea. According to V. Braun and Clarke (2006), the 4th phase of analysis involves the review and refinement of the themes identified in the initial analysis. This was a process of ensuring that the data in the themes gelled meaningfully and one which was aided by regular peer review and regular team debriefing which also supported the identification of any biases and further assisted conceptual development.

The data was also viewed through the lens of content analysis, the aim of which was to describe and quantify the phenomena described in the themes systematically and objectively. This did not merely involve counting words, but rather identifying repetitions and meanings within the context of the participant's responses (Sandelowski, 1995). Once the Thematic Map was satisfactory and the process of revision and review did not seem to be adding anything substantive, the 5th phase, that of defining and naming the themes, was undertaken. This was a process of analysing the data within each theme and identifying what each was about or was able to tell about the research question. Some themes were quite complex and could be broken down into subthemes for clarity. The use of the content analysis approach supported the thematic analysis by identifying and quantifying patterns of language use and the means connecting that language to the themes emerging from the data.

The 6th and final phase of the analysis process occurs via the 'writing up' of the results (as described in Chapter 4A). V. Braun and Clarke (2006) describe this as telling the "complicated story of the data" (p. 23). The aim of this aspect of the process was to provide a coherent account of what the data is telling about the research question in other words, the identification of the clinicians' views, understandings and expectations of a VMS for hand hygiene auditing, as well as the quantification of the frequency with which these ideas and concepts were raised. In addition, an understanding of the importance and meaning attributed to these parameters was also illuminated. The findings of Study 1 informed the development and practical implementation of VMS for hand hygiene compliance which were subsequently trialled in Study 2.

STUDY 2 – FEASIBILITY AND TIME EFFICIENCY

Aim of the Study

The aim of Study 2 was to assess the feasibility and time-efficiency of video-based approaches for hand hygiene compliance auditing as compared to the contemporary method of direct human observation by a trained observer. This meant asking and answering the question as to whether the use of video camera technology could collect and subsequently audit the data required to ascertain hand hygiene compliance in a manner consistent with the WHO My 5 Moments for Hand Hygiene. Furthermore, testing of various technical features, such as the use of the Bluetooth beacon activation as a part on ongoing development and refinement, was able to occur.

Study Design

Study 2 constituted the experimental intervention aspect of the overall pragmatic study. This involved a trial in simulation as described below.

Data Collection

A proof-of-concept trial of VMS was implemented to audit the recorded simulated practice within the Q-Class Rooms of the New South Wales Biocontainment Centre (NBC), a purpose-built facility for case-management and high-level isolation at Westmead Hospital. Initially, it had been planned to also conduct simulation exercises in the simulation laboratory of the School of Nursing at the University of Sydney. However, the University HREC failed to provide approval of the project, despite multiple modifications to the proposed methodology. The initial application proposed used volunteer HCW actor participants. However, this was rejected on the basis of potential coercion and hence, employing HCW participants via an employment agency was suggested. This was again rejected with the suggestion that volunteers be utilised for the trial. This cyclic rejection and

resubmission, along with delays caused by the COVID-19 pandemic and the associated lockdowns, necessitated the trial being conducted at only a single site.

In total, six simulation exercises were conducted over two days, as outlined in Table 3. These were between 22 and 49 minutes in duration and involved three different clinical scenarios and several different recording modalities, including a trial of the VMS specifically developed as a result of Study 1 [APPENDIX J].

Table 3. Overview of proof-of-concept trial in simulation. Includes details of scenarios and the recording modalities used each day.

Day	Location	Simulation Scenario	Recording Modality
1	Q-Class Rooms of NBC	Basic physical assessment and history taking in a patient with fever	• Pre-existing fixed cameras • Trial VMS cameras
		Returned traveller with an infected leg wound (approx. 2 hours)	
		Care of a patient with suspected TB	
2	Q-Class Rooms of NBC	Basic physical assessment and history taking in a patient with fever	• Pre-existing fixed cameras • Trial VMS cameras • Single fixed camera at observation window
		Returned traveller with an infected leg wound (approx. 2 hours)	
		Care of a patient with suspected TB	

Scenarios were developed by the researcher, who is a practicing clinical nurse consultant and checked for clinical accuracy by members of the research team and by practicing clinical educators [APPENDIX K]. Simulation, according to J. R. Duncan, Kline, and Glaiberman (2007), is a technique where a scripted scenario imitating real-world interactions replaces real-world experiences for education, training, skill assessment, clinical rehearsal and/or research purposes. The aim of the scenarios in the context of the study was to provide realistic representations of clinical care to be captured by the recording technology and to encourage the participants to relate to the 'patient' in natural way. This was distinct from the more typical aims of scenario-based simulation exercises in healthcare which is to engage participants in problem solving, learning or assessment activities. To promote realistic HCW/'patient' interactions, the actors were provided with a script and 'back story' to guide their responses to the HCWs. This included the use of props such as serology results, radiology images and charts, as well as artificial wounds, body fluids and medications. 'Patients' were also cued by the researcher at various points during the scenario to report specific symptoms or to reveal pertinent information. The scenarios also included prompts or triggers for the performance of hand hygiene and the use of PPE. This was done to ascertain whether compliance with such practices could be audited from recorded footage. That is, was it

possible to identify the need for (opportunities) and performance of (Moments) from the recorded footage. The actual compliance rates were relevant only in the context that it was able to be measured and not in and of itself as an outcome measure per see.

Three data collection modalities were used in the study: (i) within patient zone pre-existing fixed-cameras (WPZ-FC) and ii) within patient zone non-fixed cameras (WPZ-NFC); and (iii) non-patient zone non-fixed cameras (NPZ-NFC).

(i) Within patient zone, pre-existing fixed cameras ( ). Training was received in the use of the pre-existing fixed cameras (Figure 3) in the NBC Q-classrooms. This area of the facility included 3 rooms (Figure 4): the donning area (two cameras), the patient area (three cameras) and the doffing area (three cameras) with the feed for each camera being displayed as a multi-view arrangement comprising the eight images. Additionally, there was an equipment reprocessing room and patient ensuite attached to the patient area which did not contain cameras. This system could record continuously with footage able to be saved and exported for review. Individual images could be enlarged and reviewed using this modality. The system utilised Milestone XProtect SmartClient_viewer software for footage review. This provided up to nine camera views at one time which facilitated tracking from space to space, for example, from the donning to patient room to the doffing area (Figure 5). The system also allowed full screen focus on a single camera view, as well as the ability to zoom, freeze, fast forward and rewind.

Figure 3. Pre-existing camera in the NBC.

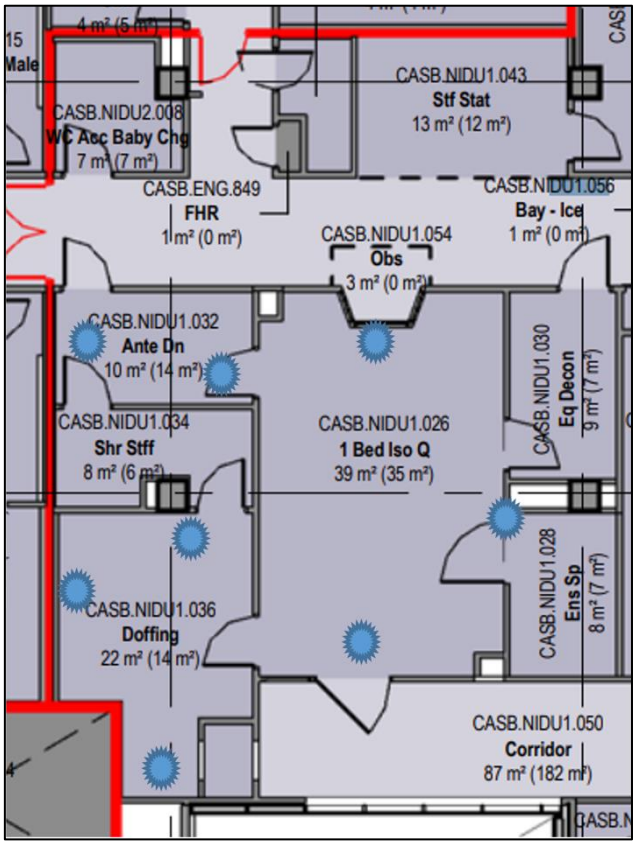


Figure 4. Floorplan of the NBC showing the location of the pre-existing fixed cameras.

Figure 5. Sample output from the fixed cameras in the NBC.

(ii) Within patient zone non-fixed cameras ( ). As part of the ongoing development of the VMS approach, cameras were temporarily installed by the provider on the day prior to the trial (Figure 6). This involved the placement of four cameras, one in each of the donning, doffing rooms and two in the patient care room (Figure 7). Given this was a temporary installation, the cameras were attached to convenient fixtures using cable ties and connected to the hard drive recorder via cables. It was noted that Bluetooth operations could be an option combined with a secure virtual local area network (VLAN) for use in more conventional settings, however the need for radiation hygiene between the rooms of the NBC preluded this option in the short term. Camera placement was attempted in such a way that while the view of the patient zone was maximised there was, at the same time, an attempt to minimise the intrusiveness of the filming. Thus, an above head of bed placement was employed in an attempt to strike a balance between data collection and patient privacy. These cameras were intended to be activated via Bluetooth proximity chips (also referred to as beacons) carried by the participant HCWs. This would mean that the cameras would only activate when the HCW was present, that camera-to-camera footage would be extracted creating a track or sequence of the hand hygiene journey and hence the overall bulk of the footage could be reduced.

Figure 6. Temporarily installed novel VMS cameras placed in the NBC for the proof-of-concept trial.

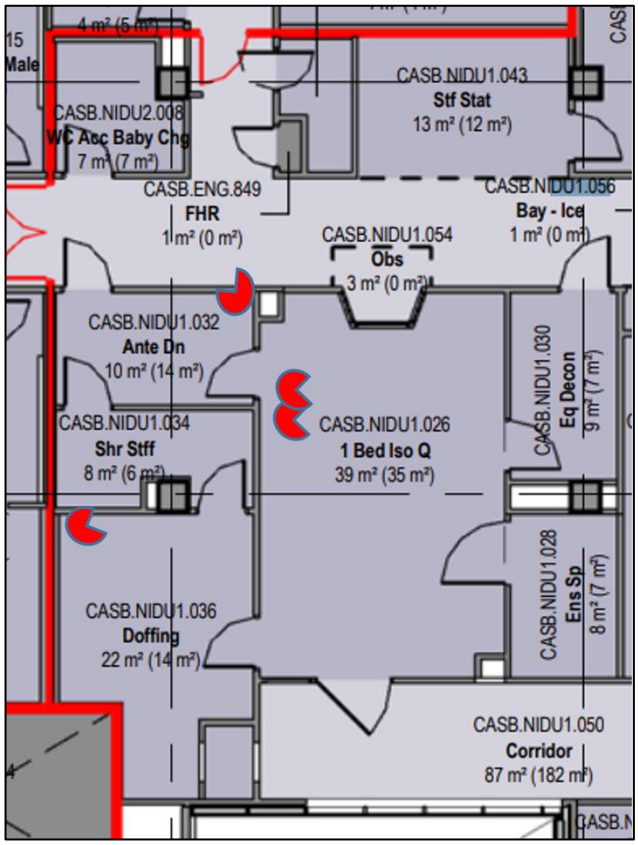


Figure 7. Floorplan of NBC showing placement of temporary Novel VMS cameras.

(iii) **Non-patient zone non-fixed cameras ( ).** As noted above, this camera was placed at the observation window (Figure 8) and recorded the same visuals which the human auditor would experience if conducting auditing from this location. This footage was to serve as an approximation for direct observation of the scenario, as well as a backup and reference for the trial.

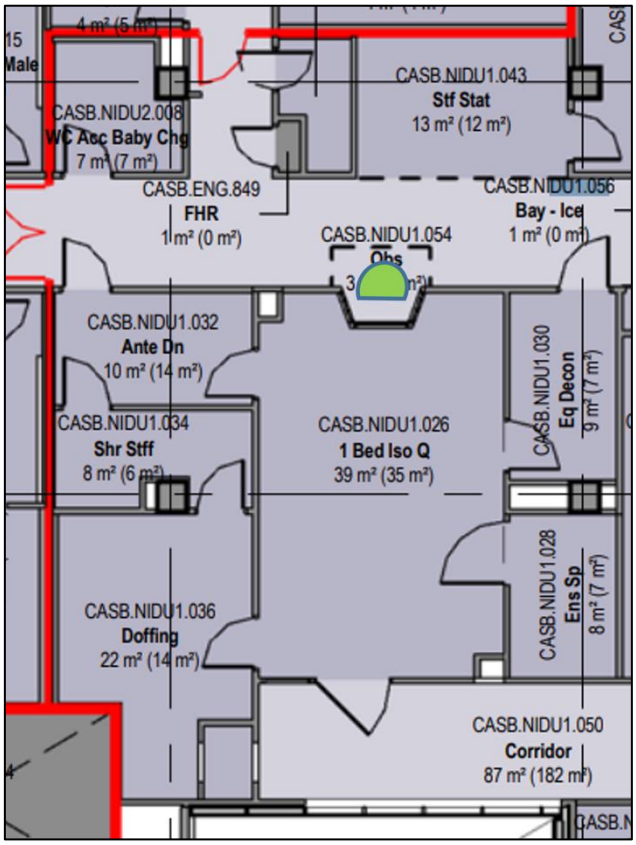


Figure 8. Floorplan of NBC with indication of placement of NPZ-NFC which mimics human auditor viewpoint.

Table 4. Footage recorded according to day, scenario and recording modality.

	WPZ-FC	WPZ-NFC	NPZ-NFC
Trial Day 1			
Scenario 1	29 Minutes x 8 camera views	29 minutes – Quad screen view	N/A
Scenario 2	49 Minutes x 8 camera views	49 minutes – Quad screen view	N/A
Scenario 3	22 minutes x 8 camera views	22 minutes – Quad screen view	N/A
Trial Day 2			
Scenario 1	36 minutes x 8 camera views	System did not record useable footage	36 minutes – single view
Scenario 2	43 minutes x 8 camera views	System did not record useable footage	43 minutes – single view
Scenario 3	27 minutes x 8 Camera views	System did not record useable footage	27 minutes – single view

Ethical Considerations

Ethics approval for Study 2 was granted by the HREC of the Western Sydney Local Health District (WSLHD) and Research Governance Committee at Westmead Hospital [APPENDIX M]. This study was

also considered low risk and adhered to the National Statement on Ethical Conduct in Human Research 2007 (2018 update). There were no variations to the approvals as granted, although no participants formally withdrew there were some issues with the actor 'patients'. One participant was caught in a COVID-19 mandated lockdown and was unable to physically attend the trial site. A second actor experienced a flare up of a chronic medical condition necessitating a last-minute recruiting drive. Volunteer participants were recruited via email from among the student population at the Westmead Medical Research Institute (WIMR). The HCW participants were volunteers from the WSLHD and included two medical officers, two nurse educators and one registered nurse. At the time of writing no complaints had been received. All participants were provided with a participant information statement and signed a participant consent form [APPENDIX N]. This information included contact information for all members of the research team, as well as for the authorising HREC.

Footage in the original (identifiable) form was viewed only by participants and by members of the research team. Footage was subsequently de-identified via the use of pixilation of facial and any other identifying features. Only de-identified footage was viewed outside of the membership of the research team and/or used in publications or presentation. Care was taken when transcribing the focus group interviews to avoid identification of participants. Sequential codes were used for each category of clinical staff and only very general demographic information was retained. Audio recordings were deleted once transcription was completed and verified. Anonymised electronic transcripts were stored in a non-networked, password-protected drive with coded identifiers stored separately. Any data containing identifiable information (e.g. non-de-identified audio or video recordings) were stored in the RDS maintained by the University of Sydney as per Research and Data Management 2015. Only the researchers had access to these files and all data will be retained for a period of five years after which it will be permanently destroyed.

The possibility of participants becoming emotionally distressed during simulations, focus groups or interview auditing was considered to be of low likelihood. However, preparations were made such that in the event that participants experienced distress or anxiety, the simulation, focus group and/or interview would be paused or ceased, and appropriate psychological support would be provided by the research team. In addition, arrangements were made for referral to the Employee Assistance Program/Hospital Social worker should the need arose.

Data Analysis

Recording was conducted primarily to establish the utility of auditing hand hygiene behaviours according to the WHO 5 Moments criteria. That is, to determine whether it was possible

to audit practice, according to the WHO 5 Moments from the footage. In addition, there was an examination of time taken, both overall and per Moment, as well as overall and per Moment "cost". Furthermore, auditor responses regarding comparative ease of use, and time efficiency of novel VMS, existing fixed cameras and direct observation methods were also obtained.

As the process of video recording gathered significant amounts of rich data, the possibility for additional uses for the footage was clearly evident. In particular, it was envisaged that there would be great scope for the evaluation of PPE usage in the context of Transmission-Based Precautions (TBP), the initiation of which formed a part of the scenarios with this possibility in mind. In addition, it appeared likely that compliance with Aseptic Non touch Technique (ANTT), another important infection prevention practice could similarly be assessed. Consideration for the analysis and evaluation of the footage with this in mind is both a future area to explore and an additional benefit of the data collection approach.

Study 1 identified the technical and methodological features of a VMS which appeared to allow the collection of data such that auditing of hand hygiene compliance according to the WHO 5 Moments should be possible. However, the interviews with key stakeholders demonstrated significant issues surrounding the acceptability of the approach which could potentially represent a barrier to the practical implementation of the technology. Study 2 demonstrated the ability to record footage with the capacity to be audited according to the WHO 5 Moments framework, as well as improvements in time efficiency as compared to contemporary approaches. However, this was a trial in simulation rather than in 'real-world' conditions. Furthermore, the question of acceptability remained unanswered and hence, would be addressed in Study 3.

STUDY 3 – ACCEPTABILITY FOR HEALTHCARE WORKERS AND PATIENTS

The aim of Study 3 was to determine the acceptability of the use of VMS as a method of hand hygiene auditing for HCWs and patients. The need to explore this question arose out of the strong themes of privacy, fear of surveillance, data storage and retention, medico-legal concerns, HCW and patient safety and potential alterations to feedback which emerged from the findings of Study 1.

Study Design

This study utilised a combination of in-depth semi-structured group and individual interviews within a pragmatic naturalistic theoretical framework alongside an online survey using both fixed (scaled) and free text responses.

Data Collection

The data collection process for Study 3 comprised of three modalities: (i) Focus group interviews with proof-of-concept trial participants; (ii) Online Survey of both HCWs [APPENDIX P] and patients [APPENDIX Q]; (iii)In-depth interviews with HCWs [APPENDIX R] and patients [APPENDIX S].

Group Interviews

All participants from Study 2 were invited to take part in post-simulation group interviews. The aim of these sessions was to explore the participant's responses to being subject to the recording process and their views as to the acceptability of VMS for auditing infection prevention practices including hand hygiene. This explored key themes of acceptability which had emerged from Study 1 and helped inform the development of the Study 3 online data collection tool and interview guides.

Group interviews were conducted immediately following the simulation exercises and a question guide was used for each focus group to ensure consistency of data collection [APPENDIX L]. A total of five HCWs participated in two separate interviews and almost two hours of audio recording resulted. As with Study 1 interviews, the group interviews were audio recorded and transcribed verbatim. De-identified transcripts were returned to participants for member checking as described previously in this chapter. HCW participants were also be invited to participate in individual interviews where they would have the opportunity to privately review the recording of their practice and reflect upon the experience with respect to the acceptability of video-based monitoring as a technique for the monitoring of infection control behaviours. All participants declined to undertake individual interviews and elected instead to review the footage and receive feedback collectively as part of the focus groups.

Group interviews were seen as useful for generating ideas and solutions and for promoting discussion, it was identified however that there was the risk that some participants may feel inhibited in the group environment. It was for this reason that individual interviews were offered in order to allow HCW participants to privately reflect upon their own practice and to explore their responses to video-based surveillance of their practice. However, all indicated that they were comfortable to review in the group setting and none appeared inhibited in their responses, feeling free to voice opinions and to disagree on some points.

Actor patients were unable to participate in post-simulation focus groups due to conflicting commitments, however they were contacted later and requests were made for participation in

online interviews using the Zoom™ platform. One actor patient participant agreed to interview. During the interview, samples of recorded footage were shared with the actor patient and their feelings and responses relating to being the subjects of filming were explored. The interview was audio-recorded and transcribed as previously described. However given that there was only one participant who undertook an interview it was deemed that there was insufficient data relating to the actor patient responses to and acceptability of, the experience of being subject to the use of VMS for hand hygiene auditing. Furthermore, given the duration of time which passed before the interview could be undertaken the possibility of recall bias could not be excluded, hence this data was not included in the study.

Surveys and In-Depth Individual Interviews

Initially, key stakeholder HCW participants were invited from members of the Australian College of Nursing (ACN) which has 11,000 members, the Australasian Collage for Infection Prevention and Control (ACIPC) which has 1,050 members, and The Australasian Society for Infectious Diseases (ASID) which has 1,714 members. Subsequent recruitment occurred via 'word of mouth' and meant that not all participants identified as members of the listed associations, however all were practicing healthcare clinicians. Recruitment of patient participants was initially via the Consumers Health Forum of Australia (CHF) which has 4,000 members and subsequently promulgated via 'word of mouth'.

Participation was voluntary, and recruitment was via email invitations facilitated by the specific association and conducted according to their individual requirements [APPENDIX T]. Designated representatives from the colleges and organisations forwarded the study information, via email to their members [APPENDIX T]. The emails included study information along with contact details of investigators, should respondents have any questions related to the study. There was also a public link to both the survey and the EOI form for interview, meaning that participants could elect to participate in the survey and/or interview. Subsequently, invitations to participate were shared with non-members who expressed interest and willing to participate and who met the inclusion criteria outlined below.

The only inclusion criteria required was status as a HCW or patients, principally members of the above associations although not exclusively so, and the ability to speak, read and understand English and to be able to provide informed, written consent in order to participate.

Online REDCap Survey

Data was collected directly from key stakeholder participants (HCWs and patients) using an online survey tool, Research Electronic Data Capture (REDCap), a secure online database application maintained by the University of Sydney.

Two separate surveys were developed using REDCap. The survey for HCWs included 30 questions (a combination of multiple choice and open-ended questions) relating to HCW opinions on the concept and acceptability of video-based surveillance for hand hygiene and other infection prevention behaviours [APPENDIX P]. Within this survey branching logic was used to separate responses from HCW who had qualifications or experience as hand hygiene auditors from those who did not. There were also additional questions for auditors relating to their current auditing practices. The second survey for patients included 21 questions (a combination of multiple choice and open-ended questions) relating to patient opinions on the concept and acceptability of video-based surveillance for hand hygiene and other infection prevention behaviours [APPENDIX Q].

Interviews

As part of the initial recruitment process, as well as again at the end of the surveys, a link was included inviting respondents (HCWs and patients) to register their interest in participating in a one-to-one interview to further explore their views regarding the use of video-based technology to monitor and audit hand hygiene and other infection prevention behaviours. This link directed respondents to a separate form so that their survey answers were not linked to their contact details. Respondents were then asked to leave their contact details in the new form. Respondents who registered interest were contacted by members of the research team via an email containing the study information and a Participant Information Statement and Consent Form [APPENDIX V]. Participants could also elect to participate ONLY in the interview by progressing directly to this option via the REDCap portal.

Following the return of written informed consent, further contact was made to arrange interviews which were conducted via Zoom™ or telephone. Interviews were guided by a pre-determined set of semi-structured and open-ended questions and took between 20-60 minutes to complete [APPENDIX R & APPENDIX S]. During interviews, participants where shown examples of footage recorded by various types of VMS, as well as a recording of direct observational auditing taking place.

A total of 24 interviews were undertaken. These were audio recorded by members of the research team, transcribed verbatim and then returned to participants for member checking as

previously described. Interview participants were separated into one of three categories: frontline HCWs (FLHCW), auditors or patients. The convenience sample included eight participants in each category as defined in Table 5 below.

Table 5. Sample size and characteristics of Phase 3 interview participants.

Code	No.	Details	Description
Patients	8	Healthcare patients or in one case the parent of patients.	Patients; any individual who had used a healthcare service in the previous 12 months.
FLHCW	8	Frontline HCW, including: • Nurses • Nurse Unit Manager • Doctors	HCWs who were NOT hand hygiene auditors, rather had been or could be the subject of direct observational hand hygiene auditing.
Auditor	8	Validated Hand Hygiene Auditors: • Infection Prevention & Control nurses • Infection control link nurse • Radiologist • Frontline clinical nurse & auditor	HCWs who were validated as hand hygiene auditors and who had experience of performing direct observational hand hygiene audits.

Interview Structure

The interviews followed a similar structure to the online surveys; however, the format allowed for the exploration of ideas to a greater depth than was facilitated by the online survey. Two separate, but similar, questions guides were used in order to ensure consistency of questioning and to assist with staying 'on track' [APPENDIX R & APPENDIX S]. All except one interview were conducted via Zoom™, with the remainder undertaken by telephone due to technical difficulties. The advantage of the Zoom™ format was that interviewing could take place at a time and place of comfort and convenience for the participants not withstanding pandemic lockdowns. The interviews could also involve participants from more diverse geographical locations than would have been practical with in-person interviews. In addition, the medium allowed the interviewer to share samples of footage as examples of the approach which illustrated the technology well. Another benefit of the Zoom™ format was the ability to assess body language, facial expression and gesture which was not possible when interviews were conducted by telephone.

Utilising the appropriate question guide (patient or HCW), the interviews started with the collection of basic demographic data such as age, location (state or territory), and for HCWs, their role, facility/unit and the length of time they had been practicing in their profession.

HCW were asked if they were hand hygiene auditors while patients where asked if they had had ever seen direct observational auditing take place. All except two HCWs were familiar with, and

had experienced, direct observational auditing of their hand hygiene practice. The two who were not familiar with the process, along with all patients (none of whom could recall having seen direct observational auditing taking place) were shown a brief (8 second) video of direct observational auditing and an explanation of the process was provided (Figure 9).

Figure 9. Example footage showing hand hygiene auditor performing direct observational hand hygiene auditing.

Questions explored participants experiences with direct observational auditing, their responses to it from the perspective being subject to the audit and in the case of auditors, their viewpoint as both an auditor and having their own practice audited. Opinions as to the validity and accuracy of the method were sought, the nature and frequency of any feedback given or received, as well as beliefs surrounding privacy relating to the process. Those who had no experience of direct observational auditing were asked to answer in the theoretical; that is, “how do you think you would feel?”.

Following the discussions surrounding direct observation, participants were introduced to the concept of VMS for hand hygiene auditing. The approach was explained and then using the Zoom™ share screen function, participants were shown two or three of the brief videos captured during Study 2 (initially two videos were shown, and then the third was added when it became available).

The **first video** was a segment the footage captured using the pre-existing camera array in the biocontainment unit (Figure 10). The 57-second video demonstrated the coverage provided by

the network of cameras and the ability to manipulate footage for review (focus in on one screen, zoom, fast forward, pause, rewind and slow motion).

Figure 10. Example of footage from pre-existing camera array (WPZ-FC) showing multiple camera view and single camera view.

The **second video** was that filmed using the temporarily installed cameras and illustrated the effect of the proximity beacon in that sequential camera activation in the presence of the HCW could occur with camera deactivation once the HCW had left the room (Figure 11). The camera placement in this instance was from above and behind the patient rather than side or front on.

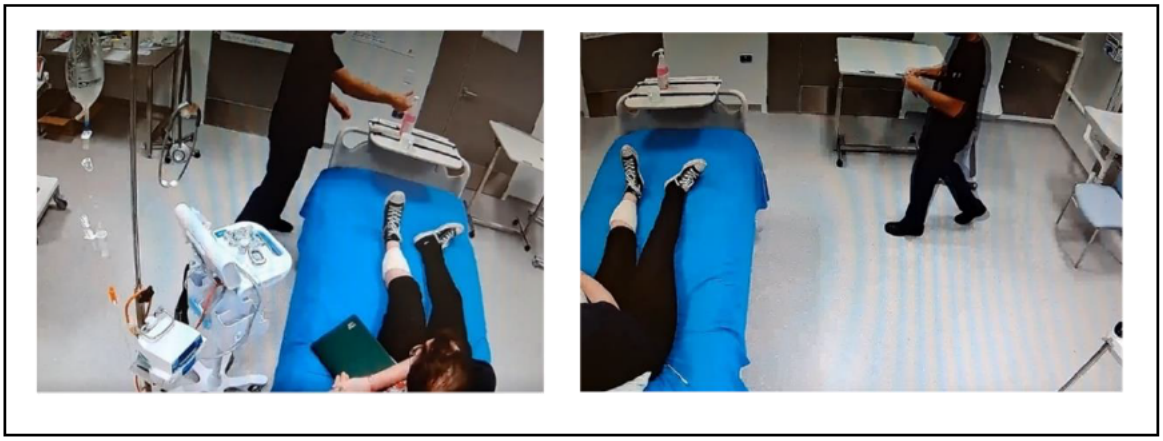


Figure 11. Sample output from the temporarily installed cameras forming part of the novel VMS, demonstrating the rear (above bed) camera positioning.

The **third video** demonstrated the use of a privacy filter which automatically detected a participant's face and applied a blurring filter (Figure 12). This video was also recorded using the temporary cameras and hence featured the camera placement above/behind the patient, as well as proximity activation.

Figure 12. Sample footage demonstrating privacy filter resulting in facial identification and the application of a blurring filter.

Following the viewing of the videos, participants were asked to discuss their responses to the concept of a VMS, the advantages and disadvantages of the approach, what technical features or methodological processes they felt would enhance acceptability, issues of privacy and consent, as well as any other concerns or opinions that they had related to the use of a VMS for hand hygiene auditing.

Ethical Considerations

Ethics approval for Study 3 was granted by several separate entities. The group interviews with proof-of-concept trial participants were covered as part of Study 2 and approved by the HREC of the WSLHD and Research Governance Committee at Westmead Hospital. The online survey and associated interviews were approved by the HREC of Sydney University [APPENDIX U]. This study was also considered low risk and adhered to the National Statement on Ethical Conduct in Human Research 2007 (2018 update). There were no variations to the approvals as granted, no participants withdrew and at time of writing no complaints had been received. All online survey participants were provided with a participant information statement as a link in the introduction of the survey [APPENDIX P & APPENDIX Q]. Consent to participate in the survey was indication by checking an "I consent" tick box and further implied by completion of the survey. Those engaging in the in-depth interviews received a link to a PICF [APPENDIX V]. The completed return of the form triggered contact to arrange participation in the interview. All PIS and PICF documentation included contact information for all members of the research team, as well as for the authorising HREC.

No identifiable information was collected via the online surveys and expressions of interest to participate in the interviews were collected via a separate form to ensure that respondent's details could not be linked to their survey answers. Participation in the interview was voluntary, and it was made clear that completion of the expression of interest did not constitute an agreement to

participate, rather return of a completed consent form was required to trigger contact to arrange the interview.

All group and individual interviews were audio recorded as previously described. Care was taken when transcribing the interviews to avoid identification of participants. Sequential codes were used for each category of participant and only very general demographic information was retained. Audio recordings were deleted once transcription was completed and verified. Anonymised electronic transcripts were stored in a non-networked, password-protected drive with coded identifiers stored separately. Any data containing identifiable information (e.g. participant contact details) were stored in the RDS maintained by the University of Sydney as per Research and Data Management 2015. Only the researchers had access to these files and all data will be retained for a period of 5 years after which it will be permanently destroyed.

The possibility of participants becoming emotionally distressed during the focus group, survey and/or interview was of low likelihood. However, preparation was made such that in the event that participants experienced distress or anxiety, the study would be paused or ceased, and appropriate psychological support would be provided by the research team.

Data Analysis

Thematic and content analysis of the group and individual interview transcripts was undertaken in the same manner as described for Study 1 earlier in this chapter and as informed by the work of D. F. Duncan (2013), V. Braun and Clarke (2006), Boyatzis (1998) and Sandelowski (1995). For the individual interviews, concurrent analysis suggested that data saturation was occurring after six or seven interviews for each cohort (Auditor, FLHCW or Patient) and was confirmed by the eighth interview for each group in that no new themes had emerged. The themes identified in the analysis of the group and individual interviews are then reported in conjunction with the results from the online survey in Chapter 4. These results explore and illuminate the acceptability of VMS for hand hygiene auditing for patients and HCWs.

Quantitative data from HCW and patient surveys were downloaded from REDCap and exported and analysed. Descriptive statistics were used to summarise outcomes. Conventional content analysis technique was used to analyse text data.

CHAPTER 4: RESULTS

INTRODUCTION

This chapter presents the results of the 3 studies exploring the utility of video-based monitoring systems for hand hygiene auditing. Each study materialised in publication in the international literature, which are also reported in this thesis.

STUDY 1 – TECHNICAL AND METHODOLOGICAL SPECIFICATIONS

Study 1 aimed to determine the technological and methodological specifications that might be required for a video-based approach to hand hygiene auditing according to the 5 Moments criteria.

Introduction

An understanding of the advantages and disadvantages of both direct observational and video-based hand hygiene auditing was essential for determining the development of a video-based approach. Interviews with clinical participants and discussions with methodological and technical experts elicited rich information, which validated and extended the material derived from the literature review, to establish what was needed.

Purpose

The first step in the development of any new approach, be it with a product or new procedure, is the precise clarification of what one is aiming to achieve. With this in mind, one focus of the interviews was to explore what participants perceived the purpose of hand hygiene auditing was with emphasis upon the currently mandated direct observation technique. It was intended that this information would help inform and clarify the purpose of the proposed video-based approach.

Participant Demographics

As noted, 27 clinicians participated in a total of 25 interviews over a four-month period. As convenience sampling was used the intent was to continue to recruit until saturation was evident. The largest cohort were the MOD participants (typically IPAC clinicians) and the data represented a large range of practice settings, geographical locations and levels of auditing experience. The coding matrix and break down of participant demographics is outlined in Table 6 below.

Table 6. Phase 1 interview participant demographics.

CODE	Title	Number	Description
CE	**Content Expert**	5	Participant engaged in jurisdictional (state) oversite of hand hygiene programs, and/or engagement (past or present) at a national level.
COD	**Collector of Data**	4	Frontline auditors collecting data on a day-to-day basis in clinical settings – often local, peer or ward-based auditors.
MOD	**Manager of Data**	16	IPAC clinicians or portfolio holders responsible for managing a hand hygiene program at facility or network level and/or training of local hand hygiene auditors.
ROD	**Recipient of Data**	2	Ward or facility managers who receive and respond to hand hygiene compliance reports.

Participants were drawn from all states in Australia, except Tasmania, and were employed in a variety of settings both public and private sector, as well as from metropolitan and rural contexts. This ranged from both adult and paediatric tertiary hospitals through to small rural health services with less than 30 beds, as well as from a state regulatory body, ambulatory and mental health settings and a dental hospital as outlined in Table 7.

Table 7. Phase 1 interview participants, breakdown of workplace type according to participant category.

Code	Public Metro Hospital	Private Metro Hospital	Public Regional Hospital	Private Regional Hospital	Community/ Ambulatory Service	Other
CE	3	1				1
COD	4					
MOD	8	1	5		1	1
ROD	2					

The majority of participants were current hand hygiene auditors and this was a deliberate strategy as they would be deemed to have expert knowledge of the direct observational auditing process which was being examined. Estimated average Moments collected per month varied considerably ranging from 0 to 400 (

Table 8). As expected, CEs had the greatest years' experience with hand hygiene auditing (average 10.4 years) followed by MODs (average 7.6 years) and CODs (3.5 years).

Table 8. Phase 1 participants – breakdown of auditing experience and average Moments collected per month according to participant category.

Code	Current Auditor	Years auditor (av)	Range	Median	Moments each month (av)	Range	Median
CE	4/5	10.4	10 - 11	10	83	0 - 200	40
COD	4/4	3.5	3-4	3.5	26.7	10 - 50	23.5
MOD	14/15	7.6	3-10	9	42	10 - 400	10
ROD	1/2	4	N/A	N/A	10	N/A	N/A

Themes emerging from the interviews illustrated four points of view as to the purpose, aim or intent of hand hygiene auditing (Figure 13): 1. *It's all about getting accurate data*, 2. *It SHOULD be all about getting accurate data* (but the direct observation method means we can't), 3. *It's all about culture or behaviour change* ('the number' doesn't matter) and 4. *It SHOULD be about culture or behaviour change* (but the drive for 'the number' gets in the way).

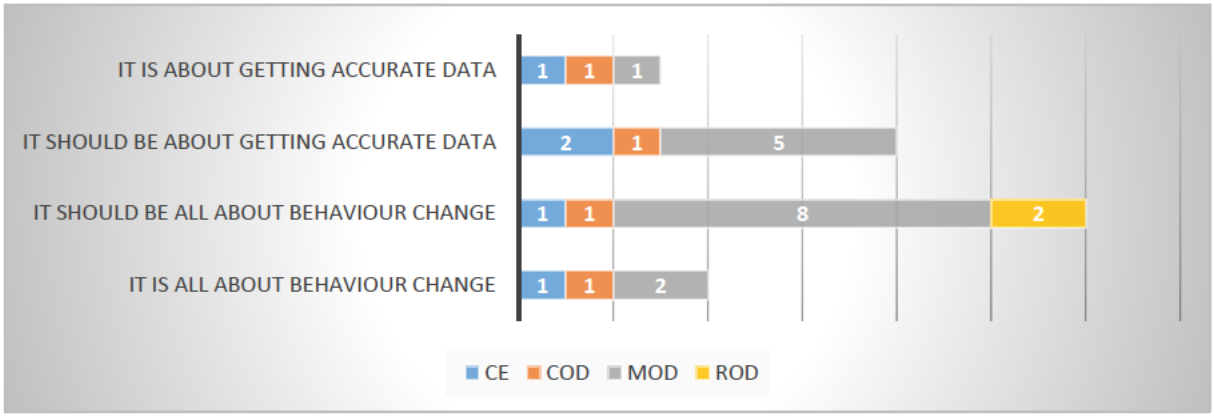


Figure 13. Count of Phase 1 participants' statements about the purpose of direct observational hand hygiene auditing. CE = content experts, MOD = managers of data, COD = collectors of data, ROD = recipients of data.

A small number of participants (n = 3) saw the primary purpose of compliance monitoring via direct observation as being the collection of accurate data with the following response encapsulating this viewpoint:

"Oh... I don't see that I'm there to change their behaviour... I mean I'm an auditor... my job is to audit" [MOD6].

One participant expanded this idea, explaining how the data would be used to inform and enable compliance improvements through culture change and educational programs. Out of 27 participants, eight stated that they believed that auditing should be about collecting accurate data but that this was not achievable through direct observation. When asked whether they believed that the "number" which was submitted to the NHHI was an accurate reflection of hand hygiene behaviours when auditing was not taking place six participants felt that it was very accurate, eight believed it was somewhat accurate or should be treated as an "indicator" only, while 11 related that they felt that the submitted figure was not at all accurate (Figure 14).

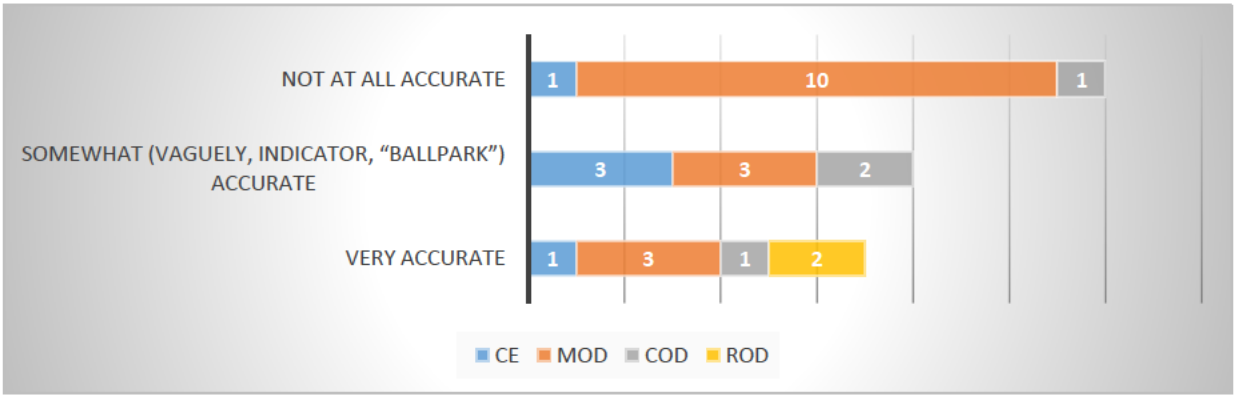


Figure 14. Participants' stated beliefs about the accuracy of the hand hygiene rate submitted to the NHHI according to participant category.

One participant related that although their facility achieved the benchmark, in contrast it was their belief:

"I think it's probably more around 30-50% compliance in real life" [MOD14].

An alternative view regarding the primary purpose of hand hygiene auditing was expressed by four participants. They described the intent of direct observational auditing as being to support behaviour or cultural change and the "number" was neither accurate nor important. Most respondents who expressed this view described their approach to auditing as highly overt (Figure 15):

"Oh, I'm an overt, I... I don't believe in covert auditing... I'm there as a colleague ... I'm there as a person to support people understanding what they could do better next time" [CE1].

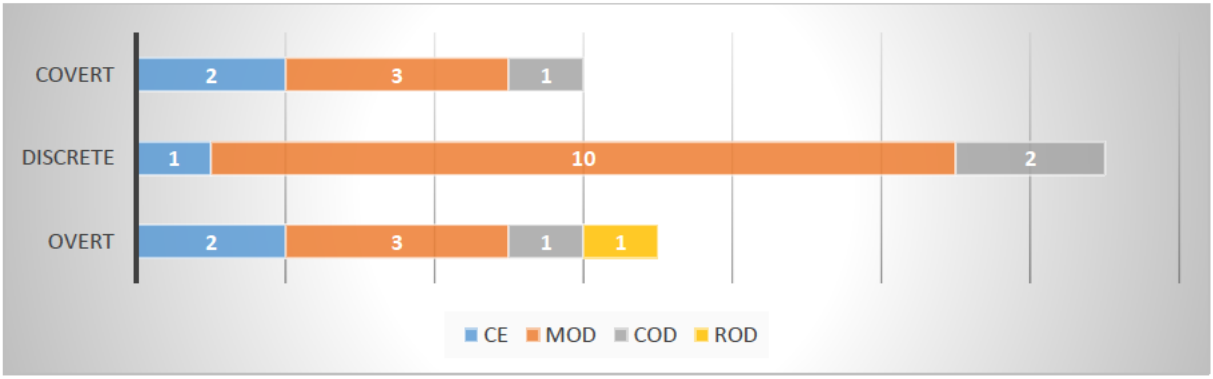


Figure 15. Auditing style according to participant.

The most commonly held view however was that while hand hygiene auditing should be about behaviour change the emphasis had shifted and the drive had become the achievement of the 'number'. As one participant explained:

> *"Everyone's so focused on the numbers... they're completely focused on their percentage" [CE4].*

Another concurred:

> *"I think that it has changed over the years... the aim has sort of morphed now into a hospital performance indicator... has moved into this performance measure that I don't necessarily agree with" [CE2].*

When asked where the impetus of this change had come from, participants indicated "management" or "executive", one of the participants stated:

> *"Executive... they just want the number... and they want it to be... they're more interested in the number than the actual behaviour" [MOD9a].*

Another agreed:

> *"... the data's become the most important thing... rather than what the data's representing" [MOD7].*

While a third went beyond a local cause for the focus on the numbers, noting:

> *"... the organisation gets hung up on the numbers because they're hung out to dry by the commission and HHA" [MOD12].*

The pressure to achieve benchmarks was seen to have impacted negatively on the compliance monitoring process and there appeared to be degree of resigned cynicism, frustration and perhaps

even audit fatigue being expressed by participants. One participant, having been assured of anonymity, related how they had been sent out to audit to achieve specific results:

> *"I think that… often I was sent out to… Ah… Audit that way… to make the figures look good" [MOD9b].*

This participant was not alone in their experiences with several others making comments which emphasize both the pressure to achieve target results with the resulting erosion of the validity of that result:

> *"… (laughs)… to end up with a better result… yeah… Pick your people you watch… pick how long you watch them for… pick your wards that you observe… you know… your number of Moments…" [CE5].*

The above typifies the views of a number of the participants and further serve to illustrate the status of the national compliance rate in the eyes of many auditors. Perhaps the most disturbing response came from a participant in a facility which wished to apply for an exemption to submission of hand hygiene compliance Moments due to low bed numbers and occupancy rates. Rather than go through the exemption application process, the participant relates how they were advised to "make up the numbers":

> *"Disappointingly I was told by someone in the department just to make up the numbers... and I… That makes me feel ill… cause… I think that if that's just to tick someone's… um… box then we're going about this so wrong" [MOD13].*

All the above serves to illustrate the degree of confusion and ambiguity which currently exists with regard to the purpose of hand hygiene compliance monitoring when even experienced practitioners disagree and appear to be unclear as to the purpose of hand hygiene auditing. Several participants indicated a belief that hand hygiene auditors were in an invidious position, wanting to improve patient safety, change culture and behaviour and to report true rates but were up against the barrier of executive mandate and benchmarks, as the following participant explained:

> *"If I'm an infection control person working in a hospital and my CEO calls me down to their office when our benchmark doesn't hit that 80% and I have to answer to them… um that puts me in an awkward position so… I'll make sure we go to areas we know there's good compliance… so we get good compliance that I can report to the CEO and everybody's happy and that's just a fact… making the infection control person between a rock and hard place" [CE2].*

The final word on the topic comes from a content expert participant, who, trying to explain one of the reasons for this situation and in doing so expresses the frustrations that many other participants also shared:

> *"Because it's easy to collect data and it's not easy to change behaviour… I'll just keep collecting data until we get what we want… it's… it's like weighing the pig over and over and hoping that it gets fat… it's not going to make the pig fat… you've got to FEED the pig… you can weigh it a hundred times and it'll never make it fatter… you've got to FEED the pig… and we just keep weighing the pig… It's horrific!!!" [CE1].*

It is interesting to note that while 11 of 27 participants identified that hand hygiene via direct observation was or should be about collecting accurate data, only five of 27 believed that the submitted data was in fact an accurate representation of normal hand hygiene practice. This further serves to illustrate the dilemma of the current methodology and the importance of the clarification of the aim or purpose of any newly developed approach. Participants spoke of being *"Benchmarked to within an inch of our lives" [MOD12],* the phrase *"tick box exercise"* was common as was the frustration of being caught between what was seen as a reportable and in some contexts *"punishable"* number, which was essentially meaningless, and a behaviour change program. Perhaps this participant should have the final word:

> *"I think that the emphasis on hand hygiene is out of control now… and it's punitive and it's not meaningful… we should be making sure we're actually adding value to the patient in the bed… you know… and if it's just a tick box exercise then we're just not doing that" [MOD12].*

Participants' View Regarding Direct Observation

Participants were enthusiastic in their discussions of the strengths, and even more so the weaknesses, of the direct observation method of collecting hand hygiene compliance data. The intent of exploring these views was to inform the development of video-based approaches such that the limitations and issues with direct observation methodology could be avoided, or at least minimised via the suitable design of a VMS.

Strengths of Direct Observation

Described by one participant as the "*best option we have at present" [MOD7]*, direct observation is, as has been discussed the current mandated data collection method in Australia and is considered the gold standard internationally. Participants were asked to identify what they saw as the strengths of using this method to collect hand hygiene compliance data. Three themes emerged from the

analysis of their responses. These themes were consistent with the literature and are defined as follows: 1. *On the spot* (immediate, contextually relevant feedback and education), 2. *Being there* (a presence in the clinical environment) and 3. *All about the patient*.

1. On the spot

Participants identified the ability to give feedback as a major benefit of direct observation, which is consistent with previous findings in the literature. Of the 27 participants, 24 were current auditors and of those, 20 variously expressed the belief that the ability to give immediate feedback was the "*greatest advantage" [MOD15],* the *"most important" [CE2],* the *"biggest advantage" [MOD1]* or perhaps somewhat cynically, *"the only good thing" [MOD7]* about auditing via direct observation.

Face-to-face interaction and feedback was seen as a way of helping clinicians make the link between their clinical practice and the theories of hand hygiene and microbial transmission in a way that more formal education could not achieve. Effective feedback was described as ideally being immediate, real-time, contextualised, face-to-face and *"actually relevant" [CE3].* Another participant noted:

> *"You can give feedback at the time and it's contextualised to what they are doing" [CE1].*

2. Being there

The positive value of a presence in the clinical setting because of the need to audit via direct observation was another theme that emerged from the data. Several subthemes were evident and these were labelled as follows: a. *Seeing other things*, b. *Doing other things*, c. *Raising the profile of hand hygiene*, d. *Building relationships* and e. *Identifying barriers*.

Respondents indicated that they would often be *doing or seeing other things* concurrently with their direct observational hand hygiene audits. This could be a means of disguising the hand hygiene auditing with other activities to increase accuracy via covert or discreet practice as previously described. Alternatively, participants related how they had incorporated hand hygiene into their daily ward round' which could also include a variety of other auditing activities such as Aseptic Non-Touch Technique (ANTT), transmission-based precautions (TBP), Personal Protective Equipment (PPE) usage, ABHR availability and sharps management. One participant explained the deliberate nature of this combination:

> *"Our hand hygiene auditing is very much tied into our daily ward round… that was a deliberate plan… so while we're doing our hand hygiene auditing, we're auditing standard precautions, whether people are cleaning equipment down between patient*

> *use… we also audit whether they're wearing correct PPE for procedures or for isolation rooms" [MOD7].*

While having a plan to collect a variety of data, including hand hygiene compliance, was common, participants also reported that being in the clinical area undertaking direct observational auditing also gave them a chance to see a variety of "things" outside the scope of formal auditing. These ranged from inappropriate or suboptimal practices through to infrastructure or equipment that needed attention. As one participant contended, it is unreasonable to expect clinicians to identify *"what the problems are" [CE1]* as they are both busy and enmeshed in their clinical practice, whereas, as an expert outsider, a hand hygiene auditor can step back and look at everything that is going on. Another participant related how she felt that this benefit of direct observational auditing was often overlooked:

> *"I think the thing that people overlook is that you never get the opportunity to stand back and observe… so it's not just hand hygiene that you see… there's other things that you would get to observe that go on, on a daily basis, that you might not notice if you're just busy going about your business" [CE5].*

Participants also cited *raising the profile of hand hygiene*, as a patient safety activity as a benefit of performing direct observational auditing. This was particularly the case where more overt approaches to auditing were in place such as the use of signs or special vests. Participants saw their role as a way of reminding clinicians about hand hygiene, or as one participant notes, of *"trying to keep hand hygiene on top of people of people's agendas… their radar" [MOD2].* Direct observation gave auditors an opportunity to provide on-the-spot education and to engage HCWs in conversation about hand hygiene. It was also seen as a way of demonstrating the value placed upon hand hygiene by the organisation. One participant encapsulated the theme when she characterised her role as a hand hygiene auditor as being like a:

> *"…moving target, you're like a moving poster… a poster goes on a wall, it sits there for 6 months and nobody knows what's on it after about a week… but if you're like a mascot for hand hygiene then it… maybe… would bring it out to the front and centre more" [MOD13].*

The process of being present in the clinical areas to perform hand hygiene auditing was also seen as an ideal time for IPAC clinicians to work on strengthening the relationship between IPAC and ward staff. Participants spoke of direct observation as an opportunity to be a "*visible presence*", of "*building bridges*", being more accessible, of having contact and interaction, of raising the profile of IPAC and on working on *"making myself available and non-intimidating" [MOD8]*. Participants felt

that even when they were on the ward specifically for hand hygiene purposes, staff would seek them out with questions:

> *"People do stop you and ask questions… it might not necessarily be about hand hygiene… the ad hoc questions are wonderful" [MOD5].*

Identifying barriers was another subtheme which emerged. Respondents related how standing in the clinical zone conducting hand hygiene audits was an opportunity to analyse hand hygiene in context and to identify the various barriers to correct practice. The barriers varied, ranging from the physical, such as product placement or workflows, through to knowledge deficits. The ability to step back and *"see what actually causes the problem" [CE4]* allowed such concerns to be dealt with at a practical level.

3. All about the patient

The patient safety and involvement theme encompassed two separate areas. The first related directly to immediate patient safety, in that participants indicated that an advantage of direct observation was that they could, and indeed did, intervene if they observed a serious issue which may have placed the patient at risk. Whilst not stepping in to prevent every missed hand hygiene Moment, auditors indicated that they would speak up should they anticipate something serious was about to occur. This centred around the obligation to ensure patients in healthcare were safe: *"The rule is… unless they're going to harm the patient there and then… you stand back… you don't interfere…" [MOD8].* This capacity to intervene was raised as a significant benefit of direct observation by 11 out of 27 respondents who spoke of "*jumping in*" or "*pulling the staff member aside".*

The second aspect of this theme related to the ability of auditors to engage with patients with regard to hand hygiene compliance. Participants described how they would often provide patients with an explanation of their presence and of the importance of hand hygiene because "*sometimes patients like to know what's going on and they ask you while you're auditing" [MOD6]*. Participants related how they felt that patients received comfort and reassurance when they were aware that of hand hygiene auditing taking place. That seeing someone advocating for them by watching the practice of those caring for them, *"so that they're aware that compliance is being checked and obviously making them feel safe" [COD2].*

The question of whether these 'benefits' could be achieved via the use of a VMS needed to be considered; as will be discussed, the lack of physical presence in the clinical areas implicit in the use of a VMS approach would preclude some but certainly not all the identified advantages of direct

observation transferring to video-based approaches. Further, as will also be discussed, some of the cited 'advantages' of direct observation represent ideal practice rather than observed reality.

Limitations of Direct Observation

Having identified the strengths of direct observation as an auditing method, participants seemed, by and large, far more enthusiastic in their discussions of the limitations of the practice. The themes emerging from these sections of the interviews highlight areas where participants had concerns about direct observation and also provide focus as to the capacity and functions which would be required of a video-based approach. The 3 major themes relating to the limitations of direct observations were, identified as: 1. *It's just not accurate,* 2. *It's resource intensive* and 3. *It's associated with negative feelings about hand hygiene*.

1. It's just not accurate

Although recognising direct observation as a satisfactory way to determine whether observed practice was compliant according to the WHO My 5 Moments, it was not seen as being accurate in terms of the rate of HCW compliance with hand hygiene under normal or non-audit circumstances. That is, respondents felt that when performed by a skilled and validated auditor, what was being recorded reflected the practice that was occurring at the time according to the WHO 5 Moments criteria, but that this result was not necessarily representative nor did it ultimately guarantee that safe patient care was occurring the majority of the time. As the following participant explained:

> *"I think that our methodology of collection… we're very confident from OUR side we're collecting our Moments to be true… but when it comes to actual care the patients are being provided… I would love to know whether the same hand hygiene Moments are in place when we're not there" [MOD5].*

Various proofs or justifications were given to substantiate the belief of the lack of representativeness of the compliance figure collected by direct observation. One was the disparity between results when data was collected by overt as compared to more covert means, as has been noted. The other frequently cited rationale for this belief was the anecdotal reporting of personal experiences with healthcare where compliance with hand hygiene was poor or did not match published rates. One participant even did her own auditing whilst she spent 3 days sitting at her father's bedside in a major hospital and noted:

> *"The best hand hygiene percentage I saw was 25% and yet on the board outside it says when they've been audited it's 84% compliance" [MOD8].*

Several causes were offered as reasons for the relative inaccuracy of the 'advertised' or reported hand hygiene rates collected via direct observation. The primary one, as is consistent with the literature, being the Hawthorne Effect. All participants reported or described being aware of the existence of the Hawthorne Effect as a response to the performance of direct observational auditing. Participants described highly overt and even theatrical hand hygiene behaviours as a response to auditing taking place. One participant described staff behaviour as "*a bit of a joke" [MOD5],* she then went on to comment:

> *"Absolutely… people change their practice when they see us… yeah… people actually gel their hands and come up and rub them… not in our faces… but rub them… 'see I'm rubbing'" [MOD5].*

Although all participants acknowledged the existence of the Hawthorne Effect, not all agreed with the significance of its impact on the submitted compliance rate. Six of the 27 felt that it had no or only a very trivial effect on the submitted data with one suggesting an impact of around 5%. Nineteen of the 27 participants, however, thought that the Hawthorne Effect had a significant effect on the submitted compliance rate and hence this 'number' did not reflect what was 'normal' practice when direct observational audits were not taking place:

> *"I'm just not confident that the data's true… I'm not confident that people are actually practicing this way" [MOD5].*

The remaining two participants indicated that although they believed that the Hawthorne Effect impacted on the documented hand hygiene compliance rate, this was in fact not important as the underlying purpose of hand hygiene auditing was to promote positive behaviour change:

> *"I also work on the theory that they're getting it right at that time… then they actually know it… so we can build from there" [CE3].*

Several other participants were able to identify a positive benefit of the Hawthorne Effect in that they believed that it highlighted when staff had knowledge deficits relating to the correct application of the 5 Moments for Hand Hygiene. Participants described how, in causing 'excessive' hand hygiene to be performed overall there was also an increase in unnecessary hand hygiene, or what one participant referred to as *"Random acts of hand hygiene" [MOD1].* This behaviour, it was contended, was a useful way to harness the Hawthorne Effect to diagnose knowledge deficits:

> *"What it glaringly shows is when people don't know what they are doing or how to approach it… and that's not their fault… that's just showing you there's a massive education or some other gap there" [CE1].*

Selection bias was seen as another reason why compliance rates gathered by direct observation were believed not to represent the reality of everyday practice. Several participants pinpointed department targets or benchmarks as the driver for selection bias:

> *"I think the benchmark has a big impact on it too… because there's ways and means that people can audit without actually… lying" [CE5].*

Selection bias was seen to take on a variety of forms; conducting audits at certain times of the day, selecting particular HCW groups to audit, deliberately choosing the more compliant staff to audit or avoiding staff known to be noncompliant. It was also reported that in some instances, specific HCW groups might be excluded, for example:

> *"Intentionally excluding groups who get it wrong… I suspect for people to get high marks and above benchmark… perhaps they limit the number of medicos that they include because they know they bring the numbers down" [MOD15].*

Poor or negative response to feedback may also impact on, not only an auditor's tendency to provide feedback in the future but upon whom they choose to audit:

> *"I've found that with some of our auditors… particularly nursing staff… they don't want to audit medical staff… they're not willing to audit someone whose practice is poor because they've had a run in with them before" [MOD2].*

Another reason for questioning the validity of hand hygiene compliance rates related to auditor skill and inter-auditor variability. Although, as has been noted, significant guidelines exist for auditor training and annual revalidation under the NHHI, respondents questioned their efficacy:

> *"Yes they are validated annually, yes we have trained them and they've answered the test and they've done all the right things… yet there are so many misconceptions… what they interpret… what they understand becomes a real problem" [MOD10].*

One participant related how she found even experienced auditors returning for refresher or upgrade training frequently displayed anomalous ideas:

> *"You find that there is certain things that they are doing that is not consistent with how they were trained and they should be doing it… people sometimes tend to add their own interpretations... which sort of defeats the whole purpose" [CE5].*

Finally, physical barriers were also noted to impact on the representativeness and subsequent accuracy of the data. Participants spoke of closed doors and more particularly the 'curtain effect'

where clinicians deliberately and at times unnecessarily drew the patient curtains in order to prevent auditors viewing their practice:

> *"You know ... people know that you're auditing and they'll pull the curtains" [MOD5].*

All of these factors combine to call into question the validity, reliability and certainly the representativeness of hand hygiene compliance data collected using the direct observational methodology, both echoing the literature and supporting the calls for an alternative approach.

2. It's resource intensive

The second theme to arise from the interviews regarding the limitations of direct observation related to the excessive time and resources required to collect the prescribed Moments. Only one respondent disagreed, stating that she did not find direct observation a resource intensive process. Nine out of 27 did not mention the time required for data collection either way, but 17 felt that it was a burdensome process:

> *"But our resources …. Auditing… God, it takes such a big impost within your work flows" [MOD5].*

Respondents spoke of direct observation as being time consuming, labour intensive and not a very practical use of time. How it was difficult for auditors to get "*off the floor" [COD4]* or to have "*protected time" [MOD14]* to perform audits. Respondents also related their frustrations as to how long it could take to collect the required number of Moments: *"It's just a hugely, ridiculously resource intensive process" [CE2].* Or as another participant commented: *"It's just such a foolish system" [MOD5].*

3. It's associated with negative feelings about hand hygiene

The final major theme related to the negative feelings and responses that the overall auditing and benchmarking process engendered in relation to hand hygiene (Table 9). Those negative feelings were at several levels, from auditors' feelings about the process, to HCWs feelings about being audited and to the overall punitive responses and reactions to noncompliance at multiple levels which combined to make hand hygiene and compliance therewith regarded in a negative light. Participants reported feelings of frustration with and at times overt distaste for the entire hand hygiene auditing process, but in particular with the direct observation methodology. One participant described auditing as "drudgery" while others spoke of it as a despised task and related the difficulties associated with maintaining enthusiasm for the process:

> *"Everyone on our team hates doing it… you know we're been doing it for so long… it's really got to be the most loathsome part of our job" [MOD7].*

Table 9. Negative language used by participants in relation to direct observational auditing.

- Punitive
- It's a bit of joke
- Police officers
- Defensive
- Sending the 'police' to check on us
- Lots of intimidation
- Some sort of 'Staff General'
- Name and shame
- Causes 'workplace issues'
- Upsets team dynamics

Beyond the drudgery associated with the task, the responses auditors and IPAC clinicians received as a result of providing feedback or results also coloured their views of the process. Participants related that they were perceived in an unwantedly negative light or as the "*police*" or, "*some kind of staff general*" *[MOD10]*. Overall, negative responses were not uncommonly reported by participants:

> *"I mean I think it can be quite confronting ... not so much for us [IPAC clinicians] ... but maybe... I think the ward auditors would find it confronting to be giving feedback... but it is still confronting for us all" [MOD1].*

It was not just those collecting the data who experienced negative responses or feelings as a result of the auditing process. Participants reported negative feelings expressed by those who were the subject of audits, relating how HCWs felt *"on edge", "awkward", "defensive"* and *"don't like that they're actually being observed" [MOD5]*. Comments, such as the ones below, highlight not only a negative response from a clinician being audited but also the low regard in which hand hygiene and auditing to assess and improve compliance is held, as one participant explained:

> *"You get told... 'why don't you go and do some real nursing' or... or... you know... 'do something useful rather than stand there observing people'" [MOD7].*

At times the auditing process was observed to be used punitively, which further added to the negative feelings about the process. One participant reflected upon her auditing experiences:

> *"I know it smacks of public humiliation and you can tell they are… I'm gonna say… belittled and if the intent is to shame people into doing the right thing... then yes, there certainly is an element of that" [ROD2].*

The provision of feedback as can be seen from the above excerpt was clearly being used in an intentionally negative way. Even if such public 'naming and shaming' was not the intent when giving feedback, participants related how staff often reacted badly, even if care was taken:

> *"No one takes feedback very well… I can tell you… I do it so gently... I am almost apologetic about correcting them and… ah… they don't take it well" [MOD10].*

Furthermore, when wards failed to achieve targets, managers were called to account and at times subjected to what might easily be deemed public humiliation:

> *"It's used as a punitive measure... and we do it… we've got 4 wards at the moment that are sitting at 50% and you know… it's name and shame... and I just don't think that's right" [MOD12].*

Although a number of participants spoke of their organisation's *"positive safety culture" [MOD9a]* and asserted that staff were encouraged to *"speak up for patient safety" [MOD9b],* they also reflected that the reality was quite different. A culture where mistakes were viewed as an opportunity to learn and improve rather than something to be fearful of was clearly desired and seen as something that would improve attitudes. As one respondent noted with a touch of frustration *"we"* needed to "*grow up"* and respond to feedback in a positive manner:

> *"I think it would be great if the culture could change… it's about safety for the patients and staff" [MOD9a].*

First Impressions - VMS

The concept of a video-based approach was described to participants and respondents were invited to give and explain their first impressions regarding the proposal. Three of the 27 participants rated their response to the concept as overwhelmingly negative. Although all participants were able to identify problems with or limitations of the proposed vision-based approach these three participants were unable to specifically pinpoint the reasons why they felt so negatively about the concept despite encouragement to do so:

> *"When I heard video monitoring, I just thought …. Oooh I don't think that's a good way to go… I just… I just don't like the idea of cameras and that's… you know… that's a personal thing" [COD1].*

Three participants were more neutral in their response, wishing to see how things went:

> *"I mean it will be interesting to see where it goes… if it does work… I mean we've got to keep moving forward and trying new things" [CE3].*

Twenty-one participants were positive about the concept. Comments ranged from guardedly positive with "*not a bad idea at al"'* through to *"great concept", "fantastic"* and *"brilliant".* Respondents spoke of direct observational auditing as having "*had its day"* and of *"growing stale"*. They expressed the need for a "*re-jig"* of the approach to auditing and of the need to try something "*smarter"* or to tackle the problem from a "*different angle",* to embrace *"technological solutions"* and overall expressed a willingness to explore some form of VMS for hand hygiene compliance auditing:

> *"Look… we definitely need to innovate in this space… because you know we're all out there doing the same thing every day and I don't think it's actually improving our rates" [MOD14].*

Technical and Methodological Issues Associated with Video-Based Monitoring Systems

Participants were encouraged to discuss what they saw as the potential for and issues with video-based auditing. The rationale for this focus was to explore the participant's views of the proposed technology and to fully flesh out the scope, purpose and potential of a video-based monitoring system for hand hygiene compliance monitoring. Content analysis was used to identify the primary technical and methodological issues and benefits associated with the use of VMS. There were 11 themes overall – four that would be considered positive and seven more negative (Table 10). Outcomes from this study were published in the international literature in summarised form [Appendix B]. The findings are presented in full below.

Table 10. Themes relating to the use of VMS for hand hygiene compliance.

POSITIVE THEMES
1. The things you might know - collecting bigger, better data
2. The things you might see - collecting other data
3. The things you might do - potential ways of using the data
4. The time you might save - efficiency of video auditing
NEGATIVE THEMES
5. Aren't we invading the patient's privacy?
6. Big brother is watching? - staff suspicion, privacy and fear of punishment
7. Will I end up on Facebook? - data storage and security
8. Are we going to get sued? - legal issues, consent and litigation?
9. You don't trust us? - damage to relationships
10. What about feedback?
11. Won't it cost too much?

1. <u>The things you might know</u>

Participants reported that the use of video-based technology was an overall way of improving patient safety through the identification of practice gaps via the collection and analysis of more valid and reliable data relating to hand hygiene compliance. Increased accuracy for the participants was defined or seen as the ability to capture and assess the hand hygiene behaviours which reflected that which occurred the majority of the time, in particular when direct observational auditing was not taking place. While validity and reliability are more appropriate descriptors, participants repeatedly used the word "accurate" in this context to describe the output data from a VMS. This accuracy was attributed to several causes including a reduction of the Hawthorne Effect, decreased selection and auditor bias and improved auditor accuracy.

A small number of participants expressed the belief that the presence of cameras would in fact increase hand hygiene compliance via a form of positive Hawthorne Effect. This, it was suggested, would be due to staff being aware of the cameras and being fearful of being caught 'doing the wrong thing' would make a greater effort to perform hand hygiene correctly:

> *"I wonder is it actually influences the staff to think... 'Oh I'm being observed'... you know... and having that in the back of their minds every day" [MOD9a].*

One participant even expressed the concern that cameras might be a distraction to staff, causing them to become anxious and to focus unduly on hand hygiene. Although they did go on to concede

however that such behaviours were also evident as a response to direct observational hand hygiene auditing:

> *"I guess some people could get a bit in edge… So that they're focusing on their hand hygiene practices rather than the task at hand" [COD2].*

Most participants however expressed opinions that whist an initial increase in compliance might be expected as a reaction to video recording, staff would quickly forget about the presence of the cameras and resume their 'normal' behaviours. Indeed, phrases such as, *"people will forget there's a camera there" [MOD2]* where used frequently in the interviews and participants indicated that HCW behaviour and hence hand hygiene practice captured by camera-based auditing would be more typical of normal practice:

> *"Less of a Hawthorne Effect certainly… Once they've been around for a while… people are not so aware that they're being watched as if someone's standing there with a clipboard" [CE5].*

Twenty participants described the resultant data as: *"much more accurate" [MOD1, 3 & 7],* or at least "*a lot more accurate" [MOD2 & 15], "a lot more real" [MOD6], "much truer" [MOD14], "a more holistic picture" [ROD1]* and that the data would be *"true, robust and valid" [ROD2].* According to one participant, the use of video was seen as "*the only objective way" [MOD12]* of collecting such information about hand hygiene practice.

In addition to eliminating, or at least reducing, the Hawthorne Effect, the use of recording technology was also seen to improve the validity and reliability of the data via a reduction in selection bias. Respondents spoke of the potential to record across the entirety of not only the day but also as one participant suggested:

> *"You could do it… any time… night and day… weekends… like oooh… the world is your oyster" [CE1].*

Eight participants specifically commented that the reduction in selection bias engendered by the use of camera technology would result in more representative data. They endorsed the capacity of a VMS to collect data on a more representative sample of HCWs, in that, the hand hygiene behaviours of all of those who came within the view of the camera would be captured:

> *"You'd get a more honest picture because you're not selectively choosing the nurses, they're… in – out… quick... quick…" [MOD15].*

Another way video recording was believed to potentially increase accuracy was related to the actual auditing process. Participants envisaged being able to pause, slow or rewind the footage to be certain of what they were seeing and auditing:

> *"If there's a lot happening you can slow down the video or reverse it… or go back and get that right… did they miss or did they grab some hand gel?" [MOD15].*

Auditors spoke of being able to take their time, and to be confident in what they were seeing and reporting. One participant noted that auditing from video footage would be much better for auditor stress levels as compared to undertaking direct observation. Auditing from video footage also gave rise to the potential to cross check results with other auditors, particularly in more ambiguous situations where clarification from colleagues could be sought. In addition, auditing from video was seen as an excellent opportunity to improve inter-auditor validity:

> *"you're looking at inter-operator reliability in that you've actually got 2 people seeing the same things… they're interpreting things the same way" [MOD15].*

2. The things you might see

Not unlike when performing direct observational auditing, the second theme highlights the potential for the use of video-based technology to collect a variety of other information or to identify potential education, procedural or physical deficits. One participant encapsulated the potential for video-based technology with this statement:

> *"I'm thinking all these things … but it would … you know ... be potentially a one stop shop for observing compliance with infection control as a whole" [MOD5].*

For example, footage recorded for hand hygiene purposes may also offer insight into needs relating to ANTT, as well as numerous other procedure-based practices. In addition, respondents suggested that compliance with Transmission Based Precautions (TBP) could be assessed from footage and that information regarding glove usage and personal protective equipment (PPE) could also be gleaned. One participant even suggested the potential to use video monitoring technology to investigate HAI's:

> *"So like with our SAB's… You'd be able to witness… to see if patients are actually tampering with their IV's as… you'd be able to get a bit more information" [MOD5].*

Video-based surveillance was also seen as another way to assess barriers to hand hygiene, such as product placement or other similar workflow issues. There would also be the potential to see a

bigger picture in terms of hand hygiene compliance and seeing the practice within the context of overall care:

> *"We're looking at it as a system… does the work flow… what enables staff to be able to wash their hands… what's stopping you? Those sorts of things" [MOD14].*

Participants also clearly expressed the belief that the use of a video-based auditing system could improve patient safety through the collection of 'better' data:

> *"Well… if the patient is our number one focus… our number one priority… why wouldn't we do this [video auditing]… we need to be able to, as an organisation, guarantee that we're reducing our corporate risk to our patients by ensuring the safest care possible" [MOD5].*

Participants saw the potential to use cameras for other patient safety measures, this included "*suicide watch" [COD4]* as well as for falls. Indeed, several participants described how 'CCTV' style cameras were already being used in this manner and saw the potential for a dual role – that is both hand hygiene and more direct patient safety via vision-based technology, for example:

> *"We're getting camera's here now in some of our aged care rooms … to try and stop people from falling" [MOD14].*

Respondents also identified the potential for cameras to improve staff safety. One participant spoke of benefits in terms of *"patient aggression",* whilst another noted:

> *"It could be supportive as well... sometimes when you have patients that are difficult... it could be supportive towards the clinical staff" [MOD5].*

3. <u>The things you could do</u>

Having identified other uses beyond hand hygiene compliance to which video-based monitoring could be employed; respondents were also excited by the potential to use the footage in a variety of ways. The intent of a video-based monitoring system was envisaged as an accurate, efficient and effective data collection and diagnostic tool rather than the provision of feedback, however the potential to use the footage to provide feedback was raised by eight participants.

A small number of respondents did recognise the potential for the recorded footage to be used in a more negative or punitive way or for the recorded footage to be used to settle arguments about compliance:

> *"Well actually here! ... let's just play it … play it back… and see what you've done… might debunk some of that stuff too" [MOD9a].*

The majority of respondents however believed that recorded footage could be used in a far more positive way to help HCWs to understand and improve hand hygiene compliance. The power of reflexivity, that being the act of reviewing and reflecting upon one's own motivations and actions, was seen to be enhanced by the ability to view one's own practice, as one participant noted:

> *"I think there's so much to be learnt from people watching their own practice and being able to review their own practice… and yeah… it would be really helpful" [CE1].*

Being able to show actual, contextual practice to individuals in a calm and non-threatening environment away from the clinical setting was seen as an ideal way to be able to provide "*more meaningful feedback" [MOD14].* Participants spoke of the benefits of showing rather than telling staff and how this form of feedback and associated reflection would be better suited to some individuals:

> *"Some people are visual learners… I think that we can sit there and talk to people 'till we're blue in the face… but you know… if we're got some video and we can show people… say… this is… well this is the reality… then it just might stick a little bit more" [MOD12].*

Most participants saw this potential use of video footage in a very positive light and as a powerful way to change practice:

> *"You could actually see and that probably may have more of an impact … because they could actually see what they're doing and they could go 'Yeah .. you're right… I am doing this not in the right order'" [MOD11].*

It was suggested that by showing staff where they could improve, it would provide more meaningful feedback than a verbal explanation which could potentially be seen as an intrusive interruption in the midst of a busy clinical day. Indeed, as one COD participant noted, this form of feedback may be something that some of the *"more conscientious"* staff would seek out:

> *"Like some of them will use it as a learning opportunity… they'll want the personal feedback… they might even want to see the tapes themselves so they can see "where did I actually miss" …some staff would… see it as a very positive thing and use it to change their practice" [COD3].*

Respondents spoke of errors made in good faith, in that people were unaware that their practice was not correct:

> *"Because you probably… maybe don't realise that you're doing something wrong until someone tells you" [CE5].*

However, it was also highlighted that this option would not be something that all staff would want or be comfortable with having what one participant described as a *"fear of reflexivity" [ME2].*

> *"That whole punitive versus improvement approach… I think I would find it [1:1 video feedback] a bit challenging at first… because everyone's a bit scared, they're doing the wrong thing aren't they" [CE1].*

Several participants suggested that the receipt of 1:1 feedback of compliance recorded via a video-based system should be optional and only provided at the request of the individual HCW themselves. This would enable staff to feel safer, more comfortable and would be generally helpful for acceptance of the approach as "*you give staff and element of control" [ROD2].*

Closely allied to feedback is education. On an individual level it was assumed that the feedback would also function as a form of education for staff, assisting them towards a greater understanding of correct hand hygiene behaviours. However, participants also envisaged a broader educational role to which the footage could be put, with 9 participants stating that this capacity would be a significant advantage of the proposed method. Some participants suggested using actual footage to demonstrate compliant or noncompliant hand hygiene practice:

> *"They could watch back and with some permission you could actually make some demonstration… education … material out of it" [MOD11].*

Participants envisaged using the footage in a form of 'post-game analysis' style review in a similar manner to a sporting coach:

> *"You have… a coach on a football team go over and watch the football match and then go through it with the players and say "this was right" and "this was wrong" … so I mean you could use it in that context" [MOD4].*

In addition, several respondents suggested that the video footage could prove a useful tool in auditor education and revalidation. The recorded footage would provide a host of 'real' scenarios for auditors to practice auditing, compare results to aid inter-auditor reliability and to discuss and learn from.

4. <u>The time you might save</u>

A video-based auditing technology was seen as having great potential to save time, and hence money, for organisations as the fourth theme describes. Thirteen respondents highlighted this

potential, particularly given that with the use of Bluetooth beacon activated cameras footage would only be recorded when an HCW was present. As noted, direct observation is a time-consuming activity and participants related how it could often take a considerable time to record the requisite Moments. Participants spoke of the potential for 'fast forwarding' the footage to speed-up the capture of Moments, as well as the benefits of recording only when a clinician was present, both condensing the footage and the time required to identify the Moments:

> *"You can speed through if there's nothing going on… so you're not standing there for 4 hours to get 5 Moments" [MOD1].*

Participants from regional or remote areas or those with multiple or geographically diverse sites could particularly see the benefits in terms of time savings. Participants related how time wasting it could be to travel to outlying facilities only to find very little HCW-patient interaction and hence few Moments to collect:

> *"It would save time and especially because we have to, in our environment… in the regions… we have to drive to our healthcare services to do our hand hygiene observations… we'd cut down many hours of travel" [MOD5].*

Participants envisaged being able to record data and then audit and review it remotely without the need to be physically present at a more distant site. Not only was this seen as a saving in travel time but also a solution to the problem of maintaining auditors in smaller remote facilities.

Being able to perform audits at a convenient time was also cited as a major advantage. As previously noted, most auditing occurs at busy times during the day in order to maximise the number of Moments collected in the shortest possible timeframe. However, not only does this represent a form of selection bias, it is also the most difficult time for auditors to be 'freed up' to conduct audits:

> *"We all have a workload and the nurses on the ward have a workload and the NUMs are not willing to get them off the ward to do the auditing so that's a huge problem" [MOD10].*

Participants spoke of local auditors being able to audit from the footage at quiet times or at least more convenient times. During 'double staff' time (shift change overlap) was often highlighted for example. As was the benefit of being able to audit in a more undisturbed and relaxed environment where they would be able to concentrate on the task:

"You can do it in a setting that's away from everyone so you can concentrate on the actual task" [COD2].

5. Aren't we invading the patient's privacy?

The negative impact on patient privacy was the first barrier to or problem with the proposed approach mentioned in many of the interviews (Figure 16). Nineteen participants highlighted breaches of patient privacy as the primary, major or most significant issue they could see with the use of VMS for hand hygiene auditing. Respondents were quick to mention patient privacy concerns as an obstacle to the technology, either as a belief they held themselves or one which would be held and potentially held up as an objection by other staff or patients:

"Well I think it's mostly about privacy, that's going to be the biggest issue" [MOD10].

Some interesting beliefs and thoughts emerged relating to the concept of patient privacy as a barrier or a problem. Some respondents felt that the patients would be very unhappy about the idea of being filmed:

"I can see with our patients… they'd be a lot of objections from the patient's point of view" [MOD11].

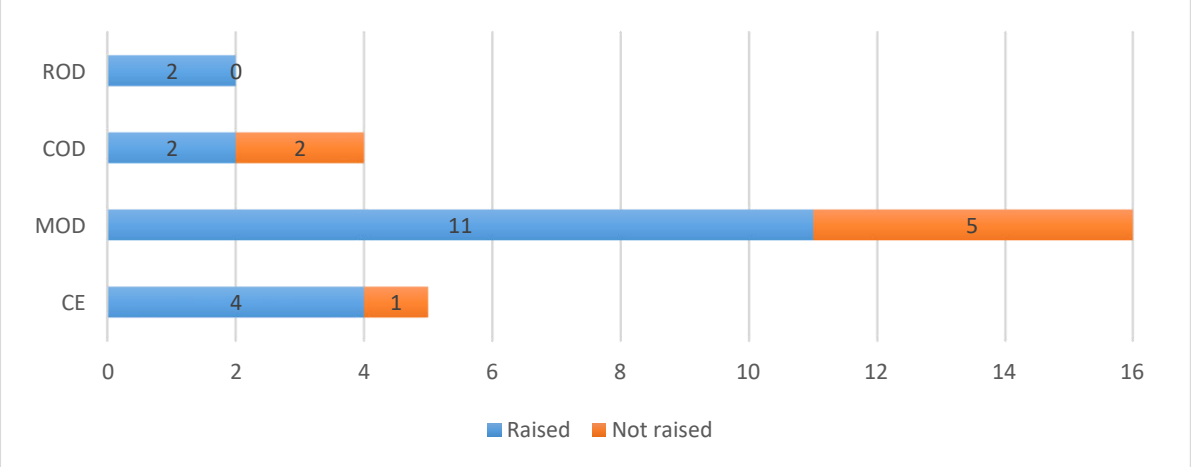


Figure 16. Participants who raised or did not raise "patient privacy" as major issue in the use of a VMS for hand hygiene compliance according to participant category.

In contrast another participant, who coincidentally practiced in a very similar context, felt that once patients understood the purpose of the surveillance that they would not object:

"I think if patients knew that this was purely for … auditing purposes… and it's just monitoring staff's behaviours to ensure compliance to safe nursing practice… I don't see why it would be an issue… I think you could quite easily bring the patients over" [COD2].

This participant went on to suggest that patients may even feel reassured by the monitoring given that the process would assist in "*maintaining patient safety" [COD2].* Another participant concurred, believing that while some patients may object, the majority would "*just go along with it" [MOD8]* and further that a small proportion would even be enthusiastic about the prospect. Working with patients, providing information and obtaining consent were all seen as important ways of overcoming HCW concerns, as the following illustrates:

> *"My concern's more around patient privacy... patient choice and decision making… um… partnering with the consumer… that aspect of things" [MOD6].*

The question of whether or not specific or individual consent would be required was raised, as were current practices around the use of signage to explain that video recording was being or may be used. Respondents described their experiences of the use of vision-based technology in healthcare such as the cameras at triage in the emergency department, body cameras for security staff, telehealth systems and cameras for falls prevention in aged care all of which were seen as accepted and acceptable:

> *"We do have CCTV in this facility… we have got CCTV everywhere… which we use from time to time" [MOD3].*

The ability of patients to 'opt out', either entirely or intermittently, was seen as another way of ensuring patient respect as part of the process. This might constitute total non-participation in the auditing process in that no filming would take place or alternatively may involve discontinuation of filming at certain times upon request:

> *"There needs to be an opt out option… the patients need to be able to say… I don't want to be videoed" [MOD11].*

While privacy was touted as a major concern by a significant proportion of respondents there were also those who believed that many patients would not be that concerned about the process. Rather, patient privacy was offered as an excuse for not using video recording methodologies when the real issue was in fact the concerns of the HCWs themselves:

> *"The first one they would fall back on .. would be… the… the patient's privacy… um … that would be the first one… and I think they would use that as a barrier to their own fear of being recorded" [MOD7].*

6. ‘Big Brother is watching?’ – Staff suspicion, privacy and fear of punishment

The above comment links to the next identified theme that ‘Big Brother’ is watching and underlines an inherent fear of surveillance. Overall, the phrase ‘Big Brother’ was used by 11 separate respondents a total of 26 times across interviews. One participant used the term four times in the 30-minute conversation highlighting the significance of this theme. This issue potentially presents the greatest stumbling block to the introduction to video-based auditing. In addition to the phrase Big Brother’, other similar language (

Table 11) was used by respondents which highlighted the concerns and clear elements of fear that HCW held or were believed to hold, in relation to being recorded. Words such as “punitive”,

Negative terminology associated with VMS		
Repercussions	Nervous	Push back
Scared	Fears	Judging
Intimidating	Confrontational	Spying
Harassment	Conspiracy	Invasive
Disciplinary	Punitive	Fear of reflexivity
“Big stick”	Penalise	Alienation
Suspicious	Punish	Reprimand

“penalise” and “punishment” were used 38 times in the interviews. Of note, all front-line clinical staff (COD & ROD) used the terminology but only 50% of other participants did so (MOD & CE). This language highlights the real fears that some HCWs expressed regarding the potential recording of their practice. Respondents related how they would “feel nervous” or would find the prospect of being recorded “intimidating” or “challenging”. The following comment is a typical exemplar:

> *“It just feels very… “Big Brotherish”… mmm… not very personal… I can just imagine if I said to my staff (laughs)… they’d be saying... you know… you’re just looking at everything we do and judging us all the time” [MOD11].*

Negative terminology associated with VMS		
Repercussions	Nervous	Push back
Scared	Fears	Judging
Intimidating	Confrontational	Spying
Harassment	Conspiracy	Invasive
Disciplinary	Punitive	Fear of reflexivity
“Big stick”	Penalise	Alienation

Suspicious	Punish	Reprimand

Table 11. Negative emotions, words and phrases associated with the use of video-based auditing for hand hygiene compliance.

These and many similar comments illustrate the concerns felt about being observed and recorded via video technology. Participants spoke of how "*everyone's scared that they're doing the wrong thing" [CE1]* and that staff would believe that if they made a mistake that they would *"get into trouble" [MOD11],* be *"hung out to dry" [CE2],* or face *"instant dismissal" [COD2].* There were also concerns that the use of video-based auditing would lead to an inappropriate and unwelcome focus on individuals: *"I think being singled out… that would be their biggest fear" [MOD14].*

Participants spoke of concerns that individuals might be *"named and shamed" [MOD12]* or have their names appear in *"the board report" [MOD12].* The unlikelihood of such fates as a response to noncompliance with hand hygiene or aseptic technique notwithstanding it is clear that such beliefs and fears are legitimately held and as such may constitute a significant barrier to acceptance of video-based hand hygiene auditing.

The reasons why participants held or reported fears of punishment relating to video recording are clearly complex and beyond the scope of this doctoral study. Yet they may be indicative of a broader punitive culture in healthcare which several respondents did touch upon as has been noted:

> *"We might like to think on an ideal world… this is not punitive… but the reality is the system likes to 'big stick' rather than 'carrot'" [ROD2].*

Another participant concurred, expressing frustration as to this approach, recommending care instead:

> *"...in everything we that we do we have to be so careful of acknowledging that no one can do things perfectly… like… I hate this obsession with perfection" [CE1].*

The expectation of 'being in trouble' expressed by participants may suggest that attempts to instil a positive safety culture have yet to prove fully successful in healthcare. Several participants described attempts at their health service to alter that mindset:

> *"…the hospital is trying to change that culture of blame to a culture of learning and improving patient outcomes that they… (sighs)… we're on a long journey" [MOD9a].*

This comment illustrates and supports the need for staff to be assured that there would not be "punishment" or "public shaming" for noncompliance detected via a video-based auditing methodology any more than there would be in response to noncompliance detected via direct observation.

Having noted concerns about identification or targeting of individuals, participants were also keen to stress the importance of reporting compliance in a non-identifiable way as a further enabler to acceptance. As is currently the case with data collected via direct observation, compliance rates collected via video-based auditing should only be publicly reported by HCW designation and Moment, with the data regarding the time and date of the audit also withheld to preclude public identification of individuals. Clearly the concern that someone could "lose their job" if they were recorded as being noncompliant with hand hygiene is a legitimately held, albeit not particularly realistic concern. However, it would seem to highlight an underlying issue regarding HCWs feelings about and responses to potentially being observed in either deliberate or more particularly, inadvertent, misconduct.

Participants stressed, however, that while it was indeed reasonable to follow up serious incidents, there was a need to give assurances that such feedback would be provided in a confidential, one-to-one manner where staff could be given a chance to reflect upon and learn from errors. As one participant noted:

> *"If there was a circumstance where I didn't follow best practice... that I was... that I had the opportunity to explain why" [CE2].*

It would clearly be important, in order to reassure staff and help to improve acceptance of the auditing methodology, to codify the procedure for management of observed noncompliance, including the provision of clarification of what would constitute a serious breach and would hence trigger activation of this pathway. One participant provided the following exemplar of how the process could be communicated to staff:

> *"Should anything... any unsafe practice be caught… staff can receive feedback and that a learning opportunity following our normal processes as far as learning goes and performance feedback and all sorts of stuff… there's going to be a process to follow" [COD2].*

Related to the fear of consequences and punishment were concerns regarding potential 'other uses' of the footage and the negative implications of those uses. While participants saw the potential for video monitoring to collect a host of information about clinical practice, it was also clear from

responses that a lack of clarity about just what information would be being recorded and exactly what was being assessed or measured would be a potential source of anxiety for staff. While it is unlikely that, were it made explicit, the auditing of ANTT would provoke any greater concern than would the auditing of hand hygiene compliance, it was a fear of the unknown uses to which the technology might be put which emerged. Some participants felt that a guarantee that the video auditing methodology would only be used for hand hygiene auditing would be:

> *"We'd have to prove we're not aiming for anything other than hand hygiene… that the material that is used will not be used against them" [MOD10].*

Again, the comment highlights the perception that the technology could be used in a nefarious or otherwise negative way. Other participants were less specific, noting that it would be important that there was absolute openness and clarity as to what and how the data would be used:

> *"Ensuring that it is gonna be used for the purpose described and not for any other purpose and governance around that" [ROD1].*

While it would be unlikely that the monitoring of ANTT or PPE would be considered any more or less problematic that hand hygiene, participants indicated quite clearly that not only was certainty required as to what would be being monitored, but also that there would be guarantees in the form of *"some documentation or evidence" [ROD1]* or even *"like a piece of paper with written things on it and signed" [MOD14]* ensuring that the technology and the resultant footage would only function and be used as agreed. In particular participants indicated that it would be important to provide specific assurances that the footage would not *"be used in staff appraisals" [COD1]* and that it was *"not gonna be used for performance reviews" [MOD2],* nor would it *"be used as a record for that staff member to be used by anyone down the road" [MOD7].*

Guarantees as to deletion of the footage following auditing were seen as a vital aspect of the system and a factor that should be incorporated in any auditing methodology as the following comment makes clear: *"Guarantee that it would be destroyed after a certain amount of time which … that it couldn't be used" [MOD7].* It is interesting that this and indeed several other participants used the words "destroyed" or "destruction" rather than deleted or erased, perhaps suggesting the strength of the imperative that the footage not be retained and that there were proofs or guarantees to this effect.

Many participants highlighted the importance of staff being involved with system implementation and of ensuring that they had a full understanding as to "*how it would work" [CE5].* Phrases such as 'communication', 'engagement', 'buy-in', 'consultation' and 'change management

roll out' abounded in the interviews in terms of ways to improve staff acceptance and overcome feelings of 'Big Brother'. Being honest and open, outlining clearly the technical and methodological functioning and parameters of the system, be it something as simple as how to turn the cameras on or off, through to the underlying purpose or intent of the approach:

> *"Listening to people's concerns and not necessarily having that answer... um… 'I hear your concerns' and it's not just a case of 'look just be reasonable, everyone's doing it… it… it's the way of the future … just get over yourself'… but 'what we are trying to do here is this…' and trying to find some common ground with them" [ROD2].*

7. 'Will I end up on Facebook?' – Data storage and security

Related to 'Big Brother' type of fears, the next theme '*Will I end up on Facebook'* encompassed concerns surrounding data or footage confidentiality. Participants stressed the importance of not only ensuring that the footage was stored securely but also the need for reassurance about, as well as details concerning the form, location and duration of that retention and storage as part of full disclosure about the system and approach as the following illuminates:

> *"Knowing how long those videos are going to be kept… and how they're stored and disposed of" [MOD11].*

As several participants commented, it was important that the footage would not end up on social media:

> *"Is there the possibility that it would ever get leaked and end up on Facebook or something like that?" [CE3].*

There were also concerns about who exactly would have access to the footage. Various acceptable caveats were suggested ranging from the quite vague "*only certain people" [MOD4]* and *"someone who is totally independent"* and is *"locked into a confidentiality agreement" [MOD15]* through to the rather more specific comment from one participant: *"The person who was on the shift and would normally have done the hand hygiene auditing" [COD4].*

The general consensus seemed to be for "*limiting the number of staff who actually see the footage" [CE4]* and for ensuring those who did maintained strict confidentiality. As a rule, IPAC staff were seen as appropriate to view the footage as were suitably qualified and validated auditors. Managers, Executive, peers or colleagues were specifically identified as not being acceptable to have access to recorded footage of hand hygiene practice:

> *"We would have to have guarantees only IPAC… infection control… will see the footage… not your manager… not your colleagues … not ... 'cause that would be the LAST thing you'd want" [MOD12].*

8. 'Am I going to get sued?' – Medico-legal issues, consent and litigation

This theme, 'Am I going to get sued', encapsulated fears relating to the use of the footage to prove some form of liability or to support litigation against individuals or organisations. The concerns expressed by participants focused on potential legal ramifications and the patients or their relatives as a source of threat*:*

> *"Doctors will be extremely concerned I think… whether it can impact of them… you know… to be sued… or whether it comes under freedom of information" [CE4].*

While some participants were concerned at an individual level, others expressed uncertainty relating to liability that the methodology and resulting footage might expose an organisation to, for example:

> *"If something's picked up on the video that would be viewed... um… you know… in a not favourable light... such as a negligent activity or something going wrong… what happens with that from a legal perspective… or you know from an organisational perspective… could it be used against the organisation?" [MOD4].*

While these concerns were clearly felt by participants, the answers to their questions were less clear. The use of surveillance and recording in healthcare clearly does occur and indeed does so with increasing regularity in the form of CCTV, video telemetry, falls or behavioural monitoring, and various procedural recording ranging from resuscitations, medical imaging through to intra-operative filming. However, the status of the footage is unclear in terms of legal discoverability and subsequent potential organisational liability. As was noted in Chapter 2, there would appear to be provisions for such footage to have protection against discoverability in the USA on the basis of being constituted as a quality improvement activity. The situation in the Australian context is unclear and as such the concerns of participants were unable to be addressed at interview. The status of any recorded footage would therefore need to be investigated and addressed as part of any future implementation of such an approach to hand hygiene compliance auditing. The legal position aside there is still the question that these comments raise ethically. Whether or not an incident could or did result in organisational or personal litigation must be considered within the context of patient harm and the obligation to undertake open disclosure of any mistake or poor practice which was identified be it via direct observation or video recording.

9. 'You don't trust us?' - Damage to relationships

The potential for the use of cameras to change or impact upon relationships was raised by several participants. A number of participants who conducted hand hygiene auditing had noted, in relation to their various activities including direct observation, that they often felt that they were seen as "the police". The question whether cameras would exacerbate or improve this perception was one which concerned participants. Some felt that the cameras would make the process less personal and more objective while others suggested that the use of video-based surveillance would indicate to clinicians that neither management nor the IPAC service "trusted" them to practice correctly:

> *"Would staff turn around and think that we're not trusting them… I think… you know… would we lose face… would our staff lose faith in in our system if they knew they were being videoed" [MOD5].*

One participant became quite passionate about the idea of cameras, even suggesting that their use would lead to HCWs feeling that their professionalism was being questioned:

> *"If you're being constantly monitored for the job you do… I don't know… if that's like… where's the trust gone that we are trained, qualified professionals… staff would see it as more of a judgement on their abilities and their training… and their professionalism" [COD1].*

Even participants who were keen to embrace the concept of camera-based auditing noted that it would be vital to include plans to overcome anticipated clinician distrust as part of any system design and implementation:

> *"The biggest disadvantage is staff negativity… if this breeds too much negativity… we've lost everything we've gained" [COD3].*

Participants also expressed concerns that auditing via video might mean less time or presence in the clinical environment focused on hand hygiene and that again that this could negatively impact on the IPAC-HCW relationship:

> *"They get to know you're around and you're not just this person who sits in an office all the time on a computer… you've got some interaction and recognition… that gives you a profile as well so you wouldn't be getting that if you're doing it all by video" [MOD15].*

Additionally, it was suggested the presence of cameras could also adversely impact the HCW-patient relationship. Participants spoke of the potential for cameras to cause staff to *"get a bit more on*

edge" [COD2] and as a consequence become more focused on hand hygiene than the task at hand. It was feared that concentration could be disrupted as could technical ability:

> *"You don't want any of the staff to feel uncomfortable so that it alters their… anything in their clinical interaction with the patients" [CE1].*

Participants also highlighted the potential for the presence of cameras to make staff reluctant to enter patient rooms for fear of being filmed: *"Is it going to stop people going into the rooms… is it going to affect patient care adversely?" [MOD4].* Not only could this impact on patient care, but if not all rooms contained cameras a form of bias might be present where HCWs preferentially attended patients not subject to filming leading to a non-representative sample.

10. 'What about feedback?'

A further theme identified was 'what about feedback?'. Fourteen of 27 participants raised the inability to give "immediate", "on the spot", "personal" or "direct" feedback regarding hand hygiene compliance as a significant problem with video-based auditing. Participants discussed the lack of immediate feedback as leading to a lack of ownership of noncompliant behaviours and as having the potential to make auditing less productive in terms of improving compliance rates:

> *"I don't think it would help because you're not getting that direct feedback, because if you're doing video… there's no body immediately involved… they'd have to go away and get looked at… then the feedback would be… you know… days… weeks later and people have forgotten what they were doing… it loses that direct feedback and education" [MOD11].*

This comment was an interesting contrast to the earlier theme '*The things you might do'* which suggested that footage would provide the ideal way to enable HCWs to review and reflect upon their own practice. Furthermore, such concerns almost contradict earlier statements about the lack of feedback being provided, particularly by local auditors.

Similarly, participants suggested that the codification of the feedback process was required or would at the least be a beneficial part of establishing the system and overcoming aforementioned fears concerning the potentially punitive uses the footage could be put to. Staff would need to clearly understand how, when and in what form feedback would be given:

> *"What sort of feedback they could expect… would it just be the same as currently or would there be some sort of different feedback system built into it where they would get to see the footage?" [CE5].*

As noted, participants felt that it was essential that public feedback or result reporting did not allow for the possibility of any individual to be identified, embarrassed or publicly shamed and that any serious breaches of practice be handled in a positive, confidential and appropriately managed manner as this participant commented:

> *"It would be useful if it was done in a positive educational framework to actually say… ah... look we have done an observation and you know… there are things we can improve" [MOD4].*

Similar to the inability to provide on-the-spot feedback, participants noted that when performing direct observation auditors have the capacity to intervene if they suspect the potential of patient harm. The retrospective nature of video auditing, however, means that this would not be possible, and harms may be observed when reviewing the footage. Although the ability to intervene to prevent harm is touted as a benefit of direct observation, the fact that less than 100% compliance is recorded indicates that potential harm IS being observed rather than prevented, a missed Moment 2, for example, indicates hand hygiene immediately prior to a procedure was omitted and places the patient at risk. Thus, it could be argued that the inability to intervene due to reviewing footage rather than live practice is less of a concern. One participant rationalised not being able to prevent such potential harms in the following way:

> *"You've got to remember that when your back's turned and you're back in your office they're still doing whatever they want" [MOD10].*

However, she does go on to note, in agreement with several other respondents, that serious breaches of practice would still need to be addressed:

> *"If you came across a serious breach of practice… and that could happen when you're recording and then you can't actually say you're not going to do anything about it" [MOD10].*

11. Won't it cost a lot?

The high cost of electronic compliance monitoring systems, including those using video, has been highlighted in the literature as a major disadvantage of such approaches. Although some participants did raise the cost of the technology as a major prohibition they were in the minority (5 of 27). It was suggested that factors such as *"capital outlay, ongoing maintenance"* [MOD15] and the time and cost to review the recorded footage could place the proposed technology beyond the budget of many health services. However, consideration was given by other participants as to the potential to save time and money using camera-based auditing. In addition, the potential to use cameras for

multiple purposes or to repurpose existing cameras to collect data which would represent a saving, was raised. Furthermore, several participants made the connection that collecting better data would lead to more focused, effective and efficient improvement strategies and hence the possibility of a true improvement in hand hygiene compliance. For example, it was reasoned that the potential reduction in HAIs could result in financial savings to healthcare networks and be highly advantageous to patients.

Technical and Methodological Specifications

The division between the technical and methodological requirements for a video-based approach to hand hygiene auditing is not clear cut. Rather, they are essentially co-dependent on how the operation of the technology informs the methods required to use that technology. Conversely, enforced, recommended or otherwise required methodological limitations, structures or caveats may limit what can be done, even if it is technologically possible. For example, the technology exists to obtain video footage that allows for the auditing of hand hygiene according to the WHO My 5 Moments, however privacy concerns, HCW opposition and/or local network policy or current legislative barriers may mean that methodological specifications of the approach need to be adjusted to cater for these factors.

Hence, the interviews with content experts, managers of data and auditors informed discussions with technical and methodological experts, which iteratively informed subsequent interviews with participants. Interview participants were able to offer few direct suggestions as to the technical functioning of a camera system designed for the auditing of hand hygiene compliance, however, the themes which emerged from the 25 interviews aided in the development of operational methodology, as well as informed the direction of discussions with technical experts.

One technical issue which was raised by participants was the importance of having sufficient cameras to capture the 'bigger picture' of HCW-patient interactions: *"It's about identifying the track … almost … of how things happen" [CE1].* What the participant is highlighting is that not all hand hygiene happens at the point of patient care or upon room entry/exit, which is the problem associated with many electronic systems. Nor is every episode of hand hygiene automatically 'compliant' according to the WHO 5 Moments criteria, but rather may be a so-called *'random act of hand hygiene'* as described earlier: *"If the cameras are only in the patient room … you're going to miss if someone comes in and has done their hands before they've come into the room" [MOD1]*. Hence, an array of linked cameras would need to be considered to be able to capture hand hygiene performed in a corridor or previous patient zones with subsequent patient contact.

Participants also highlighted that cameras needed to be purposefully positioned to obtain a good view of the room to be able to assess when and how patient or procedural contact occurred and to correctly attribute hand hygiene Moments:

> *"You'd want some really good vision in a room… well I don't know how many cameras you would need… I guess that would be my first thing... even if you've got cameras there… are they going to be positioned in the best spots" [CE2].*

Participants warned that camera technology would need to be able to mesh with existing hospital Information technology (IT systems), for example: *"It has got to be, obviously, compatible with existing systems you have in the hospital" [CE3].* In addition, several respondents noted that it was important to make sure that the cameras were safe from theft, as one noted: *"Not removable… because it will probably walk" [MOD4].*

The repurposing of existing cameras or footage for auditing hand hygiene was also suggested, this included those cameras installed for staff security (e.g. CCTV), suicide watch, fall prevention or procedural cameras such as intra-operative or video telemetry (EEG). These suggestions along with the themes from the interviews combined in a continuous and circular process to assist in the evolution of the technical development of camera-based approaches.

Summary

Study 1 examined the technical suggestions of respondents, the strengths and weaknesses of a video-based approach and synthesised discussions held with a range of technical experts. The result was the development of the technical and methodological specifications for a video-based approach to hand hygiene auditing (Table 13). Study 2 involved the investigation of the feasibility and time efficiency of the use of video-based monitoring systems for hand hygiene auditing utilising a trial in simulation to capture simulated HCW patient interaction.

Table 12. Summary outline of the technical and methodological specifications of video-based approach to hand hygiene auditing as derived from Phase 1 interviews and discussions with technical and methodological experts.

Theme	Subtheme
Purpose	• Collection of accurate hand hygiene data secondary to reduction in biases • Cost efficient and effective data collection process
Process	• Use of proximity activated cameras in patient zone and connecting common areas to record HCW patient interactions with remote auditing of footage according to the 5 Moments • Ceiling mounted wide angle cameras connected to secure, remote hard drive via data point and/or VLAN

	• Cameras activate only in the presence of a Bluetooth beacon carried by HCWs
Technological Specifications	• Cameras are secure and cleanable • Cameras are positioned so as to minimise facial identification (e.g. ceiling mounted, wide angle, automatic facial pixilation) • Cameras activated by a tag/beacon
Ethical issues	• Consent obtained as specified by local legislative mandate • Signage and 'recording in progress' notifications to advise that recording is or may be taking place
Privacy Issues	• Legislative 'permission' for within-zone recording for quality assurance purposes clarified and codified • Data is stored in a protected manner and deleted after use as 'permitted' my legislative mandate • Footage is viewed only by specified accredited users
Legal issues	• Legal status of footage (discoverability & disclosure) clarified by legislative mandate
HCW Concerns	• Footage only used for specified purposes (e.g. Hand hygiene auditing) and not retained as part of staff records, performance reviews or other punitive uses. • Feedback process codified (e.g. 1:1 confidential feedback of practice provided only at the request of the HCW, public reports preclude the potential to identify individuals) • Management of serious incidents detected on footage codified – including definition of 'serious incident' and management process

STUDY 2 – FEASIBLITY AND TIME EFFICIENCY

Study 2 explored whether video-based technologies had the technical capability to record clinical interactions in a way that allowed hand hygiene compliance to be audited according to the WHO 5 Moments criteria. It further aimed to establish the relative time efficiency and the relative cost-to audit of this approach.

Participant Demographics

There were two distinct participant populations for this study. First, there were volunteer staff from the Infectious Diseases Unit at Westmead Hospital. This included registered nurses and registered medical officers who undertook simulated patient management scenarios. Participation was voluntary and represented an educational opportunity for participants, as well as a data collection methodology for the study. Second, there were simulated patients. Initially, student actors were invited to participate on a voluntary basis undertaking the role of patients according to the specific scenario and being cared for by the participating HCWs. However, illness and the sudden imposition of a further lockdown related to the COVID-19 pandemic necessitated a last-minute recruitment drive and several PhD students from Westmead Institute of Medical Research (WIMR) kindly volunteered to take the roles of patients. This change did not require any alteration to the

ethics approval for the study given that all participants gave informed consent with regard to their participation. In addition the fact that participants had a healthcare background was not significant in terms of bias as the focus of their participation was to provide a context for the volunteer HCWs in order to assist them to engage in naturalistic clinical practice such that the opportunity for and performance of hand hygiene could be recorded and subsequently audited according to the WHO 5 moments criteria.

As indicated in Table 13, a significant amount of footage was recorded over the two days of the proof-of-concept trial, with a total scenario duration of 206 minutes (3.4 hours) from start to finish. This was captured by a variety of systems as outlined in Chapter 3, including the within patient zone – fixed cameras (WPZ-FC), the within patient zone – non-fixed cameras (WPZ-NFC) and the non-patient zone – non-fixed cameras (NPZ-NFC).

Within Patient Zone – Fixed Cameras (WPZ-FC)

The footage was reviewed by the researcher (KMcK), who is a current Gold Standard auditor of more than 10 years' experience, to determine the technical capacity to audit according to the WHO 5 Moments criteria from the recorded footage. The NHHI tools were utilised to conduct the auditing using essentially the same process as would have occurred with in-person, direct observation auditing [APPENDIX W]. Initially this process took time to adjust to, however it was anticipated that the process would become easier with further experience and skill development. Viewing the eight feeds simultaneously cast to a large screen was found to be the easiest method. In contrast to the non-patient zone – non-fixed camera (NPZ-NFC) footage, this view allowed participants to be tracked from camera to camera as they moved between rooms and captured hand hygiene opportunities and/or Moments that occurred outside of the patient zone. The footage was also able to be viewed at an accelerated rate, paused, or rewound when required. The system also had the capacity to enhance/zoom individual views so that practice could be verified.

Table 13. Comparison of scenario duration and time taken to audit from recorded footage - including number of Moments identified and compliance rate.

Day/Scenario	Duration of simulation (minutes)	Time to complete audit (minutes)	Time saving (minutes)	Number of Moments	Correct Moments	Compliance rate
D1/S1	29	13	16	8	7	88%
D1/S2	49	21.5	27.5	24	23	96%
D1/S3	22	15	7	10	7	70%

D2/S1	36	24	12	17	14	82%
D2/S2	43	29	14	41	38	93%
D2/S3	27	17.5	9.5	11	9	82%
Total	**206**	**120**	**86**	**111**	**98**	**88%**

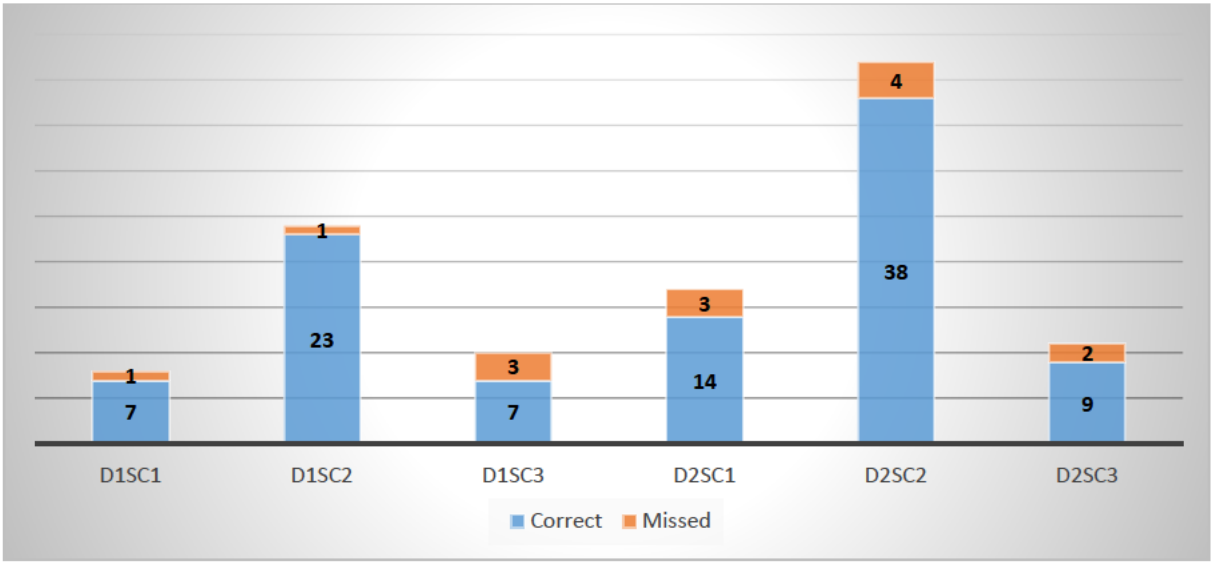


Figure 17. Within Patient Zone – fixed cameras (WPZ-FC) – overall Moments according to scenario.

On Day 1, the total simulation duration on was 100 minutes, with an auditing time from the WPZ-FC system footage of 49.5 minutes. During this time there were a total of 42 Moments collected, of which 37 were 'correct', giving an average compliance rate of 88% (ranging between 70 - 96% depending on scenario). Fifteen episodes of unnecessary hand hygiene were also observed. This represented a saving of over 50 minutes in auditing time and a collection rate of approximately 70 seconds per Moment. In terms of cost-based on an average auditor wage of AU$50 per hour, the overall cost of auditing from this footage was AU$41.25 or approximately AU$0.98 per Moment.

Footage recorded by the WPZ-FC on Day 2 was compared with data gathered by NPZ-NFC. The total simulation duration on Day 2 was 106 minutes. Auditing of these scenarios from the footage recorded via the WPZ-FC took a total of 69.5 minutes, which represented a collection rate of just over 60 seconds per Moment. In total, 69 Moments were collected of which 61 were correct (and eight missed) according to the WHO 5 Moments criteria, achieving a compliance rate of 88% (range 82 - 93%) with 23 episodes of unnecessary hand hygiene including several episodes of the application of ABHR to gloves. Overall, auditing cost for the scenarios was AU$57.92 or approximately AU$0.84 per Moment.

Figure 18. Sample of footage recorded and subsequently audited using the pre-existing cameras in the NBC – the multiple camera array meant that the HCW hand hygiene journey could be followed, and compliance could be measured according to the WHO 5 Moments.

Figure 18 footage from WPZ-FC showing both close-up and multi-camera views. Table 14, Figure 19 and Figure 20 show the results of the footage analysis with a breakdown according to Moment and HCW classification as is typical with current NHHI reporting requirements.

Table 14. Breakdown of hand hygiene compliance according to scenario and Moment as audited from footage recorded with the pre-existing cameras in the NBC demonstrating the capacity to audit according to the WHO 5 Moments.

	Day 1			**Day 2**		
	Total Moments	**Correct Moments**	**Compliance rate**	**Total Moments**	**Correct Moments**	**Compliance rate**
Moment 1	13	12	92%	20	19	95%
Moment 2	5	4	80%	16	12	75%
Moment 3	7	6	86%	19	17	89%
Moment 4	14	12	86%	12	11	92%
Moment 5	3	3	100%	2	2	100%
Total	**42**	**37**	**88%**	**69**	**61**	**88%**

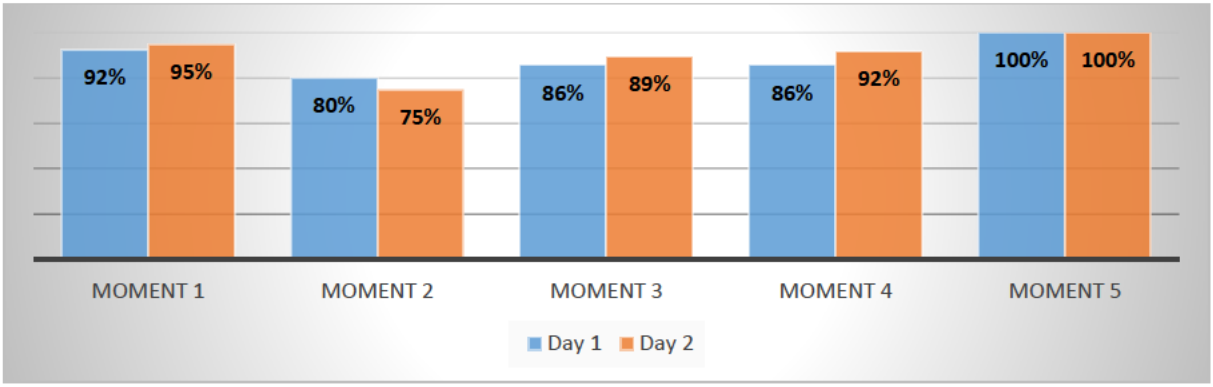


Figure 19. Hand hygiene compliance according to trial day and Moment as audited from footage recorded with the WPZ-FC in the NBC – demonstrating the ability to measure compliance according to the WHO 5 Moments.

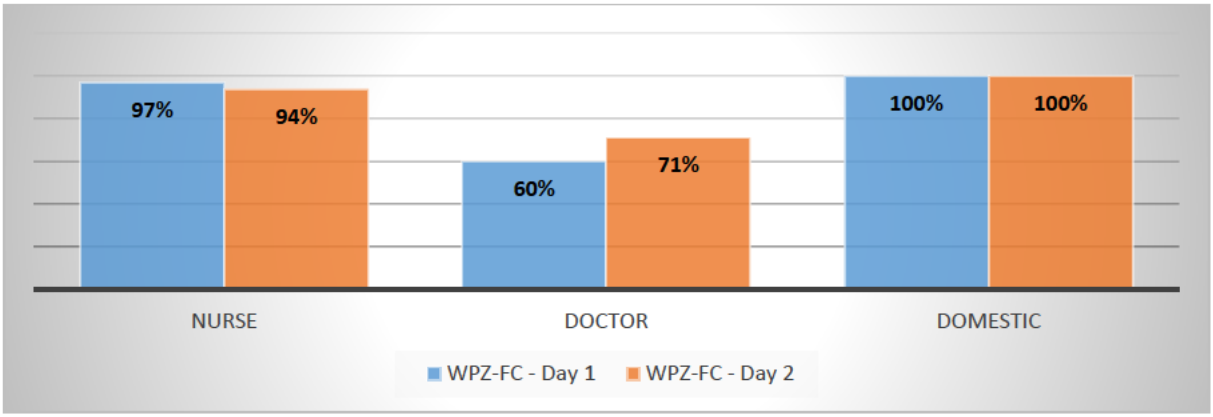


Figure 20. Overall hand hygiene compliance according to trial day and HCW as audited from footage recorded with the WPZ-FC in the NBC – compliance is according to the WHO 5 Moments.

Non-Patient Zone – Non-Fixed Cameras (NPZ-NFC)

The footage from the Non-Patient Zone – Non-Fixed Camera (NPZ-NFC) highlighted the general challenges related to direct observation auditing and the specific difficulties of the methodology in the context of auditing for a room in which transmission-based precautions are enacted. A total of 106 minutes of footage was recorded via the observation window where a human auditor would be required to stand to conduct hand hygiene audits. At times the view of the auditor was obstructed by equipment, fixtures or healthcare workers meaning that not all hand hygiene Moments or requirements could be assessed. Furthermore, hand hygiene performed prior to entry to the patient room or following exit where not visible from this vantage point. This reflected reality of actual clinical auditing. That is, in the context of a patient requiring transmission-based precautions due to an infectious condition, the auditor would be unable to enter the room due to the need to minimise exposure, and hence the avoidance of non-essential personnel within the patient zone (Figure 21).

Figure 21. Views from Non-Patient Zone – Non-Fixed Camera (NPZ-NFC) showing an auditable hand hygiene Moment and an obstructed view.

The review of the NPZ-NFC footage was undertaken as a 'one-off' viewing on a single large screen. There was no pausing, fast forwarding or rewinding of the footage to maximise authenticity of the experience as compared to actual direct observation auditing. The experience of auditing was very similar to performing direct observation auditing in a clinical setting, with the exception that there were no distractions or interruptions during the process (Figure 22).

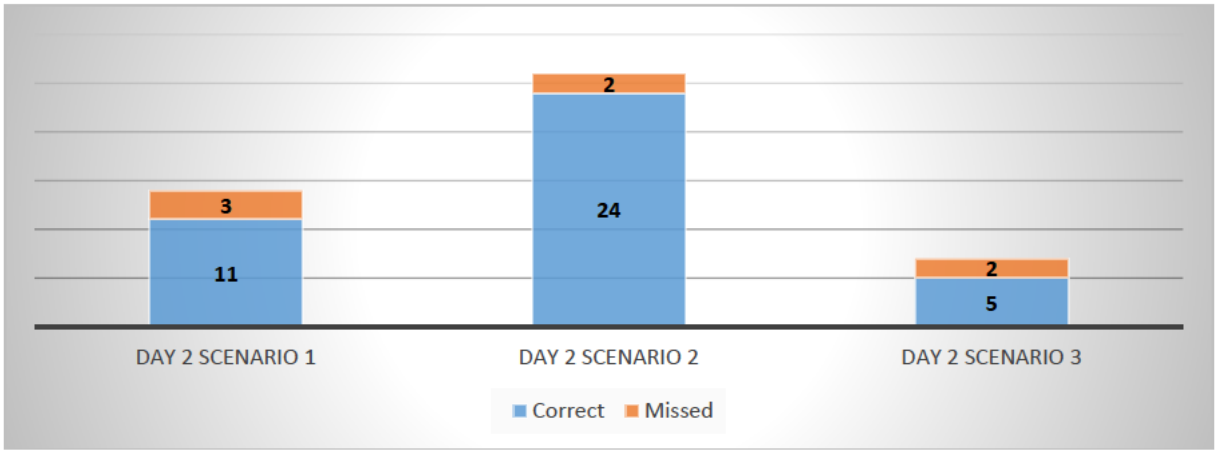


Figure 22. Hand hygiene compliance as audited from footage recorded with the NPZ-NFC in the NBC – demonstrating the ability to measure compliance according to the WHO 5 Moments as a proxy for the view of a human auditor conducting direct observation.

As outlined in Table 15, a total of 47 Moments were extracted from the 106 minutes of footage. This is a lower number than identified from the WPZ-FC footage and is most likely to be due to a combination of obstructed view and the lack of ability to view activity occurring in the anterooms. Of the 47 Moments, 40 were correct as per the WHO 5 Moments, with an overall compliance rate of 85.1%. In terms of collection rate this was approximately 2¼ minutes per Moment. Due to obstructed view, it was assumed that not all Moments which occurred or should have occurred could be assessed. It was also noted that there were at least 19 episodes of what appeared to be unnecessary hand hygiene, including several where a participant applied hand rub to gloves on four occasions which is incorrect practice.

In terms of a cost per Moment, based on an auditor wage of AU$50 per hour and the 47 Moments collected from 106 minutes of footage, auditing this would equate to a of AU$88.33 overall or approximately AU$1.90 per Moment.

Table 15. Overall compliance according to Moment as measured using footage recorded with the Non-Patient Zone – Non-Fixed Camera.

	Correct Moments	Total Moments	Compliance Rate
Moment 1	11	12	91.7%
Moment 2	8	11	72.7%
Moment 3	14	15	93.4%
Moment 4	6	8	75.0%
Moment 5	1	1	100%
Total	**40**	**47**	**85.1%**

Within Patient Zone – Non-Fixed Camera (WPZ-NFC)

The primary aim of this phase of the study was to establish the utility of video-based technology to audit hand hygiene behaviours according to the WHO 5 Moments, as opposed to the use of proxy measures such as product consumption or entry/exit. To this end, the focus of the footage analysis was the determination of whether all 5 Moments could clearly and easily be identified and audited. The use of the WPZ-NFC as part of the trial was to enable the investigation of the utility of an installed camera system in terms of the ability to audit according to WHO criteria, as well as exploring the benefits of beacon activation, the consideration of alternative camera positioning and the identification of potential further technical refinements to the approach (Figure 23).

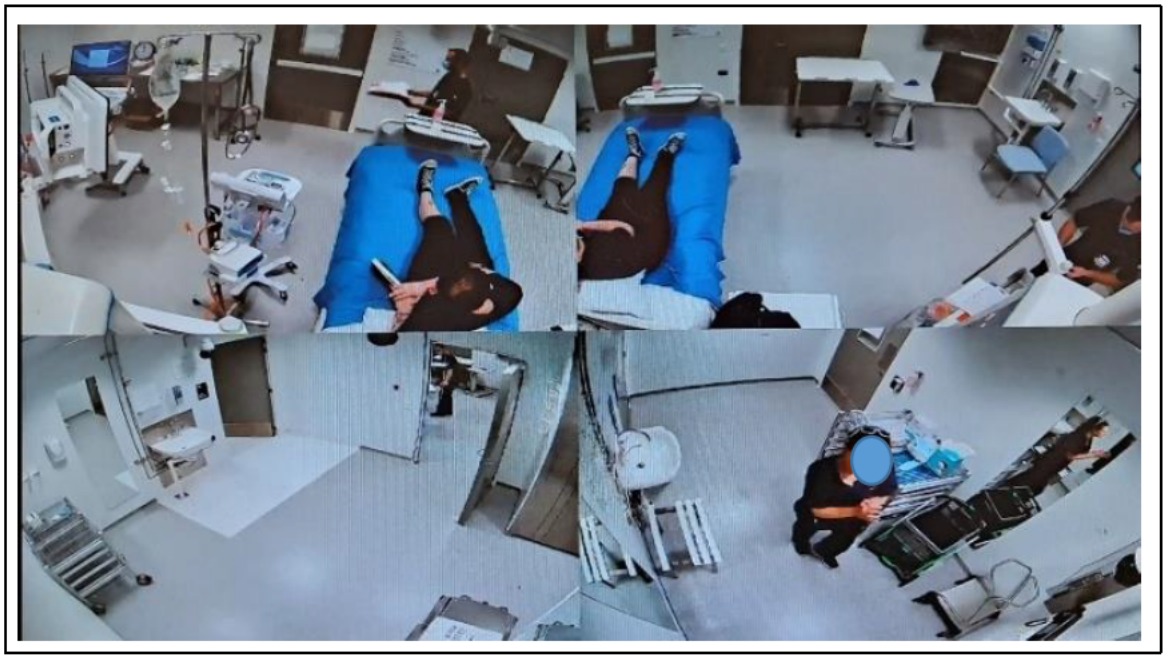


Figure 23. Sample footage exported from Within Patient Zone – Non-Fixed Cameras showing the quad-camera view.

Unfortunately, the WPZ-NFC was beset with technical problems during the trial resulting in sub-optimal footage output, however the experience provided valuable learning opportunities with which to guide the further development and refinement of the technical and methodological specifications.

The output of the WPZ-NFC for Day 1 yielded a total of 42 Moments, of which 37 were correct. This was the same yield as the WPZ-FC. Auditing from the recorded footage was possible although somewhat more difficult compared the footage taken from pre-existing cameras.

As noted earlier, it was anticipated that the output from the cameras would comprise of a stitched together 'track' of the individual HCW with sequential footage from each camera to the next as triggered by the proximity of the Bluetooth beacon. However, this feature of the system did not function as planned in the initial stages. The problems were eventually addressed, and shorter samples of the tracked footage were successfully obtained as an example of the approach. However, the bulk of the footage was provided as a quad screen view showing the output of each of the cameras individually. If this output had been synchronous, then auditing would have been simple, however there was a variable lag between the images meaning that it was at times very difficult to follow the HCW journey from room to room or within the patient care area where two cameras had been placed. In addition, there was a small, but significant unrealised blind spot in the patient care area which may also have inhibited the completeness of the hand hygiene record, although it is noted that the yield of Moments was the same for the WPZ-NFC and the WPZ-FC approaches.

Another issue with the data from the WPZ-NFC was the need to review the footage using VLC media player, which is a free and open-source cross-platform multimedia player and framework that plays most multimedia files, and various streaming protocols. However, this software has certain limitations. Principle among them is the inability to easily and precisely rewind the footage due to the use of a progress bar and a speed-limit on the 'fast forward' option of only 1.5x normal. This difficulty highlighted the importance of having high-quality footage review capabilities to maximise the efficiency of the auditing process.

Nonetheless, auditing of the footage according to the 5 Moments framework was possible. Overall, the compliance rate over the three scenarios was 88%, which was the same as that recorded via the pre-existing cameras. Measured compliance according to Moment and HCW was also the same.

In terms of time taken to review the footage, the use of VLC media player as a review tool limited the speed with which the footage could be reviewed and made rewinding awkward and imprecise (Table 16). Interestingly, the 3rd scenario was audited more quickly with the WPZ-NFC as compared to the WPZ-FC. Scenario's 1 and 2 however took longer to review with the WPZ-NFC as compared to the WPZ-FC, although both were shorter than the overall duration of the scenarios (Figure 24).

Table 16. Comparison of the time taken to audit using WPZ-FC and WPZ-NFC versus the overall duration of the scenarios.

Day/Scenario	**Modality**	**Duration of scenario**	**Time taken**
D1/S1	WPZ-FC	29 minutes	13 minutes
	WPZ-NFC		22 Minutes
D1/S2	WPZ-FC	49 minutes	21.5 minutes
	WPZ-NFC		32.5 minutes
D1/S3	WPZ-FC	22 minutes	15 minutes
	WPZ-NFC		13.5 minutes

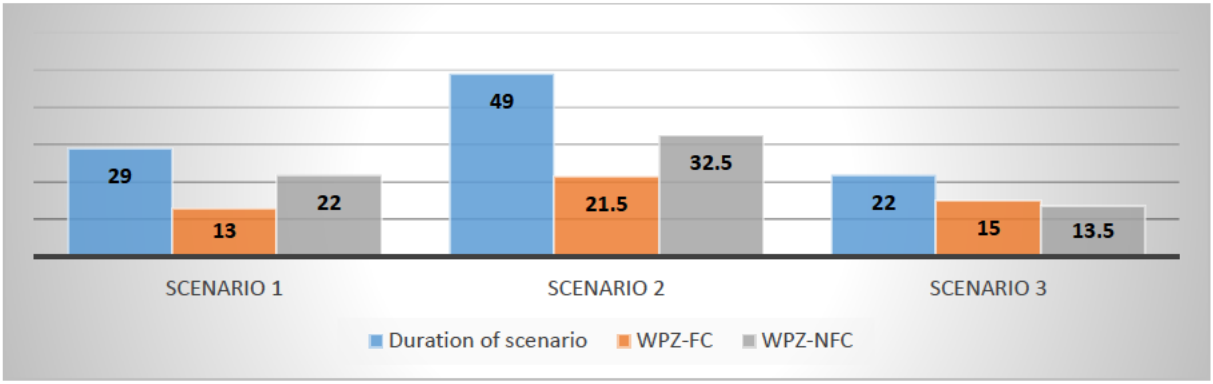


Figure 24. Auditing time according to scenario and method in comparison to overall duration of scenarios – trial day one.

Unfortunately, the WPZ-NFC output from Day 2 of the trial was not able to be audited at all. Again, this footage was presented as a quad-view rather than as stitched tracked footage according to individual beacons. The hampering factor preventing auditing was twofold. First was extremely poor and variable synchronisation of images in the quad-view (Figure 25). At times, there were up to ten-minute differences or lags between the recorded subjects exiting from one camera's field of view until their entrance into the next, when in reality it was a matter of a few seconds as they passed from one room to the other (noting that the patient care area was captured by two separate cameras).

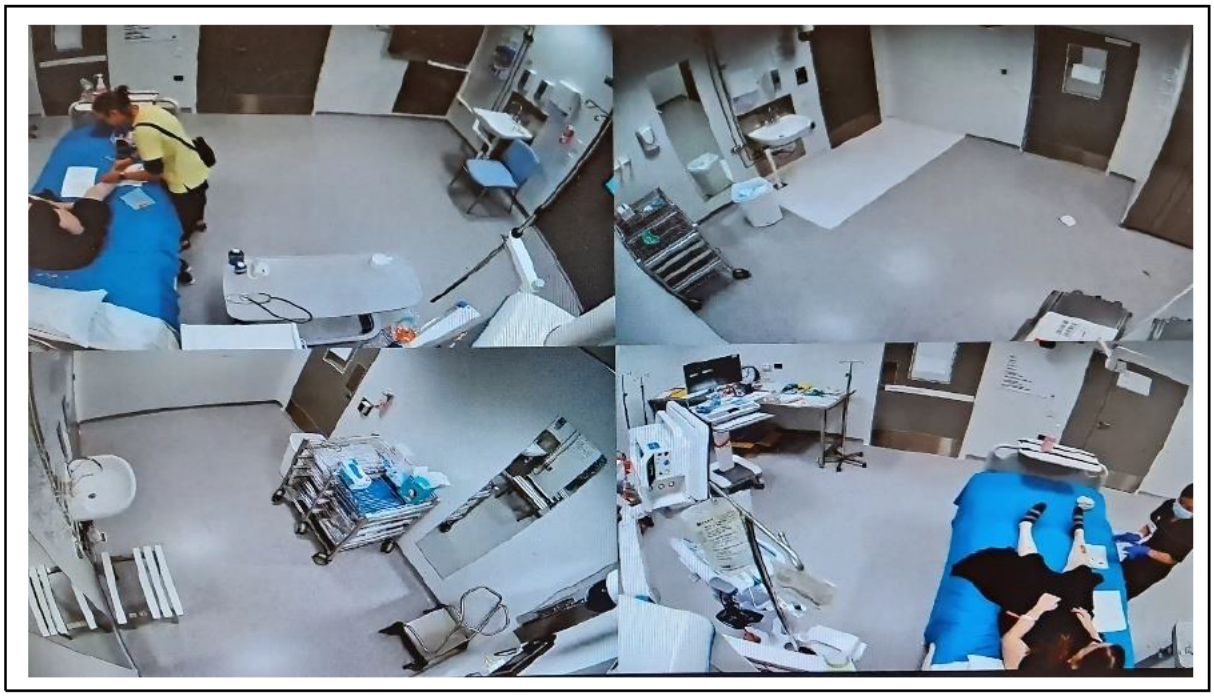


Figure 25. Quad screen view illustrating lack of synchronisation. Top left image and bottom right showing the activity in the same room but with an approximately 10-minute discrepancy in timing.

The second problem with the footage from Day 2 of the trial was a regular rebooting of the cameras throughout the recording – meaning that considerable periods of activity were lost as the footage blurred and refocused (Figure 26).

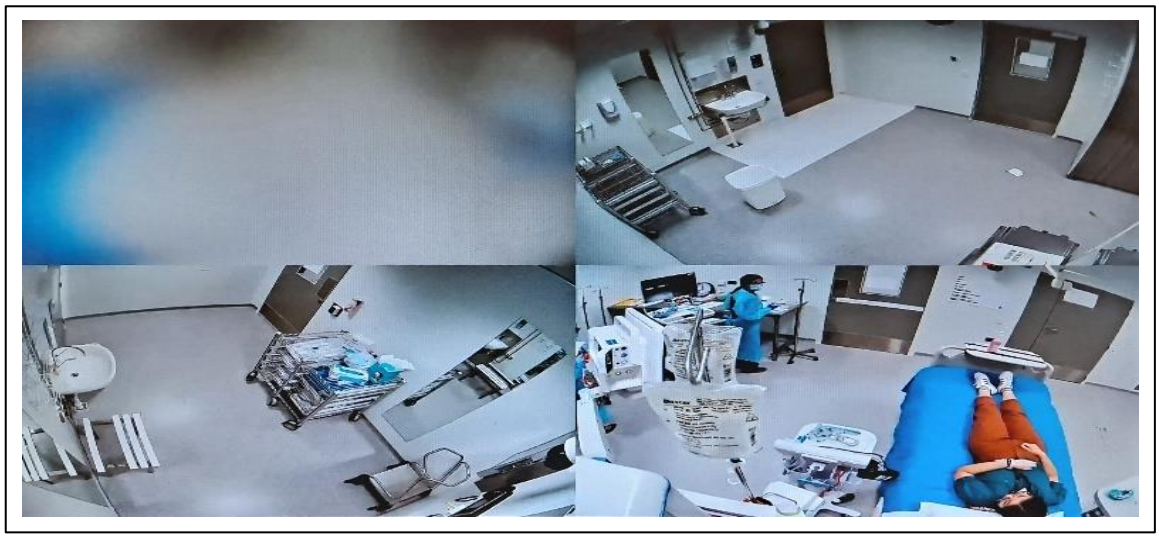


Figure 26. Sample of Day 2 footage illustrating the rebooting of the camera and subsequent loss of footage.

Table 17 below indicates a comparison of auditing time and compliance rates according to both scenario and data collection method while Figure 27 and Figure 28 demonstrate the ability of the approach to derive compliance rates according to all 5 Moments and HCW designation.

Table 17. Comparison of Moment yield and time taken to audit across all recording approaches.

Day/Scenario	Modality	Duration of Scenario (minutes)	Number of (correct) Moments	Time taken to audit (minutes)	Compliance rate
D1/S1	WPZ-FC	29	(7)8	13	88%
D1/S1	WPZ-NFC		(7)8	22	88%
D1/S2	WPZ-FC	49	(23)24	21.5	96%
D1/S2	WPZ-NFC		(23)24	32.5	96%
D1/S3	WPZ-FC	22	(7)10	15	70%
D1/S3	WPZ-NFC		(7)/10	13.5	70%
D2/S1	NPZ-NFC	36	(11)14	36	79%
D2/S1	WPZ-FC		(14)17	24	82%
D2/S1	WPZ-NFC		Unable to audit from footage		
D2/S2	NPZ-NFC	43	(24)26	43	92%
D2/S2	WPZ-FC		(38)41	29	93%

D2/S2	WPZ-NFC		Unable to audit from footage		
D2/S3	NPZ-NFC	27	(5)7	27	71%
D2/S3	WPZ-FC		(9)11	17.5	82%
D2/S3	WPZ-NFC		Unable to audit from footage		

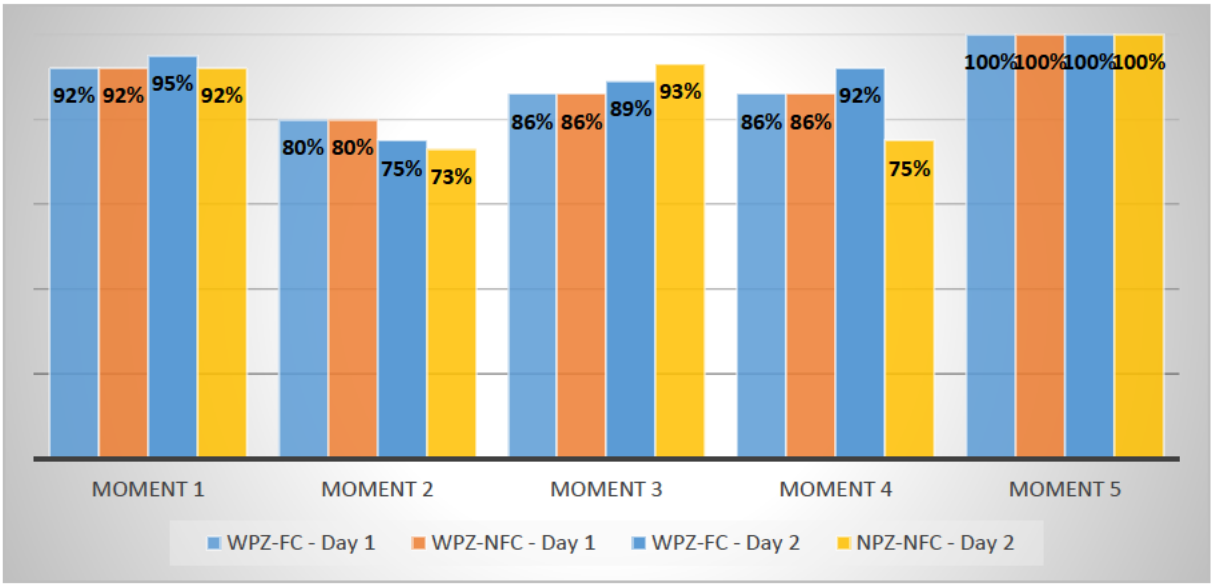


Figure 27. Comparison of compliance according to method and Moment – overall Day 1 and Day 2 of trial.

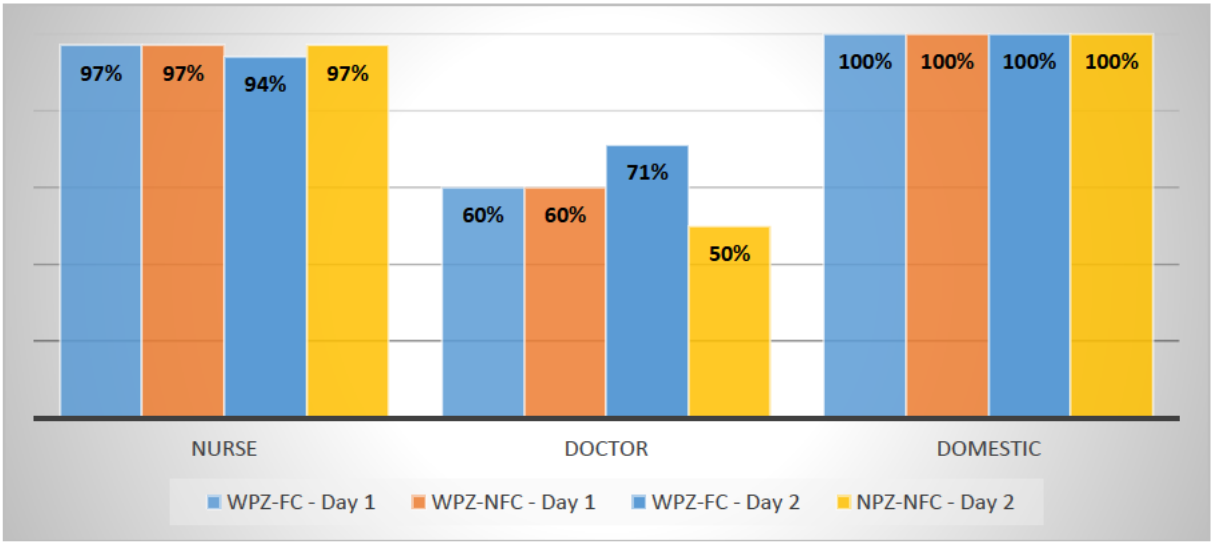


Figure 28. Comparison of compliance according to method and HCW – Day 1 and Day 2 of trial.

Other Uses for the Footage

It was theorised that the recorded footage could also be used for other purposes. The rich data collected meant that auditing of other infection prevention behaviours was clearly possible. This included the initiation of TBP, including correct and safe PPE donning and doffing procedures, glove

use and overuse and the adherence to correct ANTT practice. This data, while interesting and a matter to be pursued at a future date, is not strictly pertinent to the research question beyond evidencing the versatility and utility of the approach.

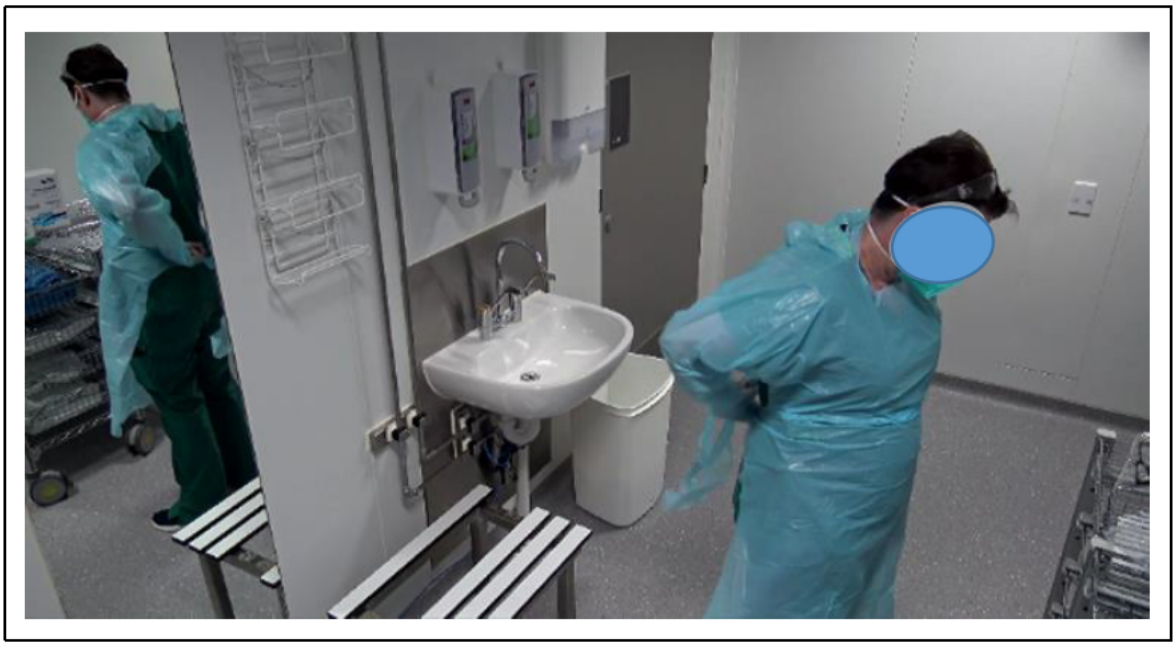


Figure 29. Example of additional uses to which recorded footage could be put as a demonstration of the utility of the approach – participant correctly donning PPE in the anteroom as audited from recorded footage.

Figure 30. Example of additional uses to which recorded footage could be put as a demonstration of the utility of the approach – a PPE breach where the participant is noted to apply ABHR to gloves.

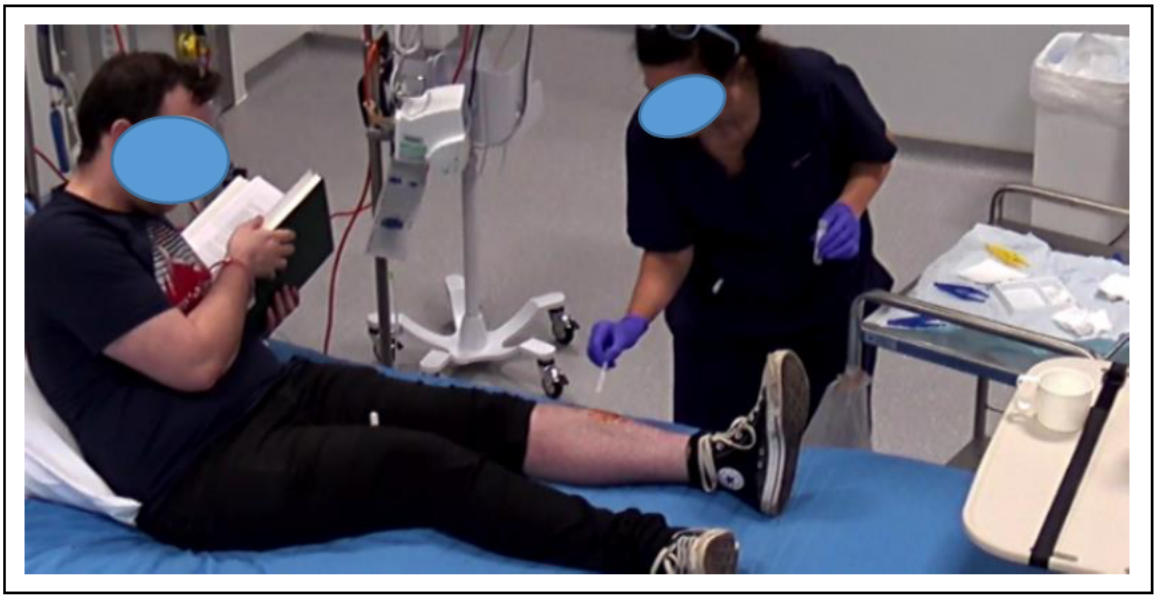


Figure 31. Example of additional uses to which recorded footage could be put as a demonstration of the utility of the approach – potential to audit compliance with ANTT using a VMS.

STUDY 3 – ACCEPTABILITY

The aim of Study 3 was to examine the acceptability to healthcare workers' and patients towards the use of a VMS for auditing hand hygiene compliance. The results of Study 2 show that video-based approaches do indeed have utility in terms of the ability to audit hand hygiene practice. There is no current published literature, however, which explores the acceptability of a VMS for both patients and healthcare workers. The results of Study 1 suggested particular methodological and technical factors could limit or enhance the acceptability of VMS methods, but these have not been the subject of systematic and sustained research.

Participant Demographics

As outlined in Chapter 3, data collection for Study 3 included group interviews with the HCW participants of Study 2, online surveys with patients and HCWs and in-depth interviews with key informant patients and HCWs. In total, 116 participants were recruited across the three data collection modalities. The sample was predominantly female and comprised largely although not exclusively of nurses. For HCW participants there was a fairly even split between hand hygiene auditors and FLHCW who were non-auditors (Table 18, Figure 32 & Figure 33).

Table 18. Participant demographics – count breakdown by gender and data collection method.

	HCW	Patient		FLHCW		Auditor		Total
	Focus Groups	Survey	Interview	Survey	Interview	Survey	Interview	
Female	4	2	6	37	8	36	6	99
Male	1	2	2	7	0	3	2	17
Total	5	4	8	44	8	39	8	116

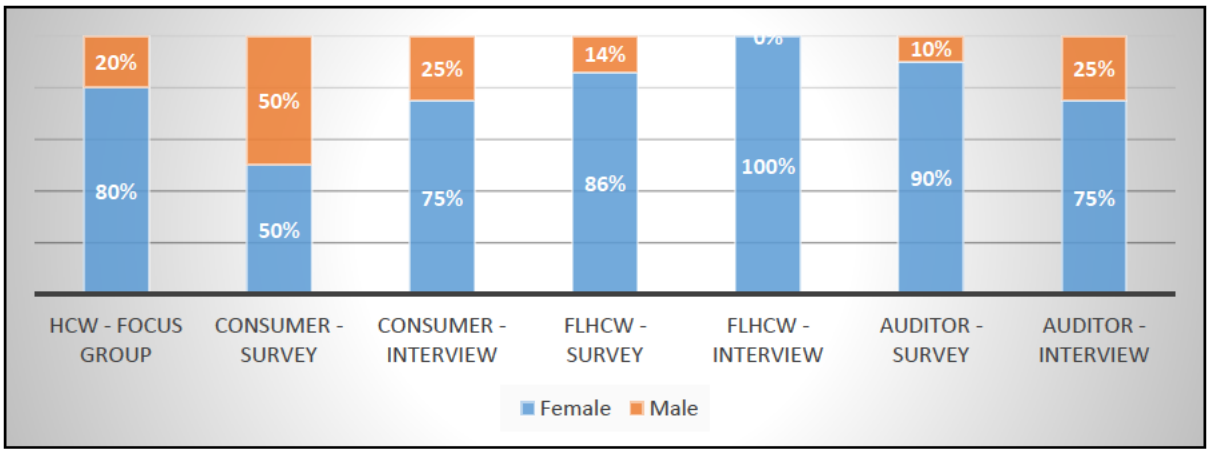


Figure 32. Participant demographics – proportional breakdown by gender and data collection method.

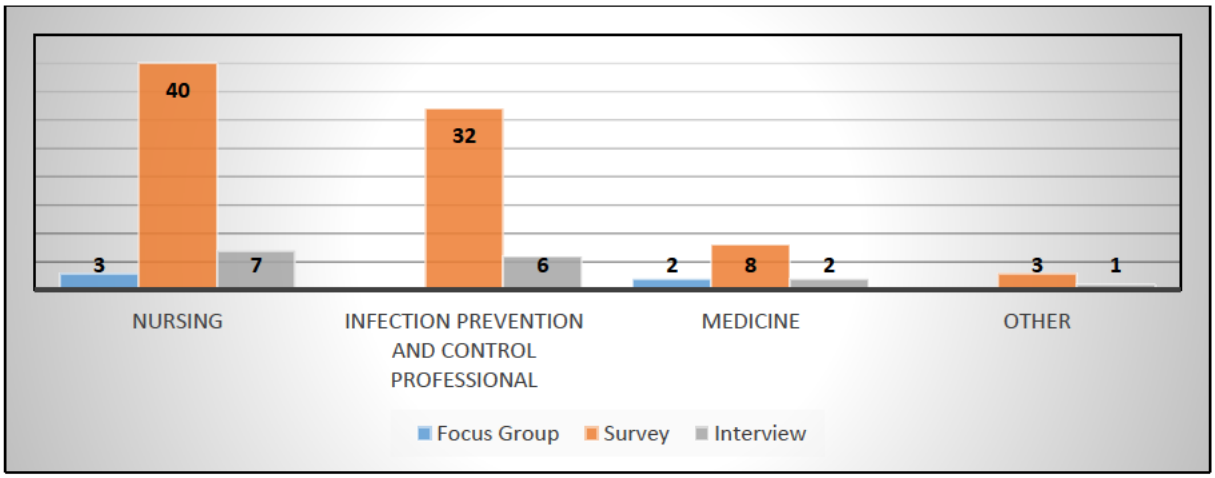


Figure 33. Breakdown of HCW participants according to professional designation.

Age (Table 19) and years of professional practice (

Table 20. Comparison of years practicing as a HCW across participant categories.

& Table 21) differed across participants and between survey and interview samples. Differences were particularly notable in the interview sample, where FLHCWs were on average younger and less experienced compared to auditors. Interviewees were also observed to have

greater years of experience as hand hygiene auditors. The ages and years of practice for the focus groups participants were not recorded as part of the data collection.

Table 19. Participant demographics – age of survey and interview participants across categories.

Age	Mean	Median	Min	Max
Surveys				
Auditor	52	54.5	34	65
FLHCW	48	47	28	66
Patient	57	61	30	75
FLHCW & Auditors	50	51	28	66
Interview				
Auditor	51	57.5	37	63
FLHCW	38.5	36.5	26	59
Patient	54	56	19	85
FLHCW & Auditors	44.5	40	26	63

Table 20. Comparison of years practicing as a HCW across participant categories.

Years Practicing	Mean	Median	Min	Max
Survey				
Auditor	18.2	15.5	1	43
FLHCW	17.7	14	2	47
FLHCW & Auditors	18	17	1	47
Interview				
Auditor	26.6	29	4	43
FLHCW	15.5	9	4	41
FLHCW & Auditors	21.6	16.5	4	43

Table 21. Comparison of the years of experience as a hand hygiene auditor between survey and interview participants.

Number of years as hand hygiene auditor	Mean	Median	Min	Max
Survey	7.2	7.5	1	15
Interview	8.4	10	1	15

All focus group participants were from NSW. In contrast, the majority of survey and interview participants were from Victoria, although not exclusively so as outlined in Figure 34.

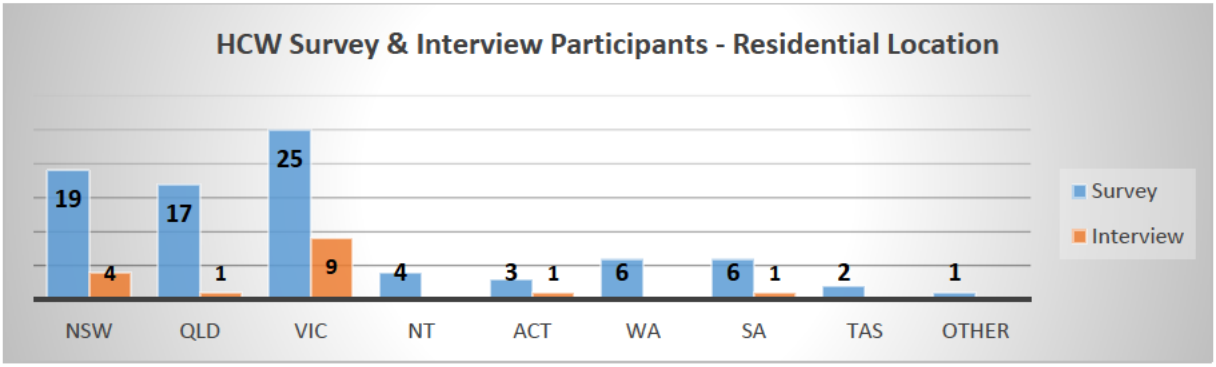


Figure 34. Breakdown of HCW Survey & Interview Participants according to residential location.

All patient survey respondents were affiliated with the Healthcare Consumers Forum, whereas patient interview respondents were a mixture of HCF members and word-of-mouth referrals. HCW who responded to the survey were primarily affiliated with one of three organisations: the Australian Collage of Nursing, the Australasian Society for Infection Prevention and Control or the Australasian Society for Infectious Diseases. ACIPC members were the most prolific respondents, accounting for 76% of the sample, followed by ACN and ASID with 14% and 10% respectively. Interview participants were largely associated with ACIPC or were referred by word-of-mouth by ACIPC members or by colleagues who had heard of the study.

Most the HCWs that responded to the survey, most were employed in an acute care public hospital in either a metropolitan or regional setting, 8% were employed in a private hospital setting and one respondent identified as being employed in a community setting. The remainder selected 'other', with the majority of these respondents specifying aged care. Interview participants were primarily employed in either public metropolitan or regional hospitals, one worked in a metropolitan private hospital, two in an ambulatory service and four in other settings (Figure 35).

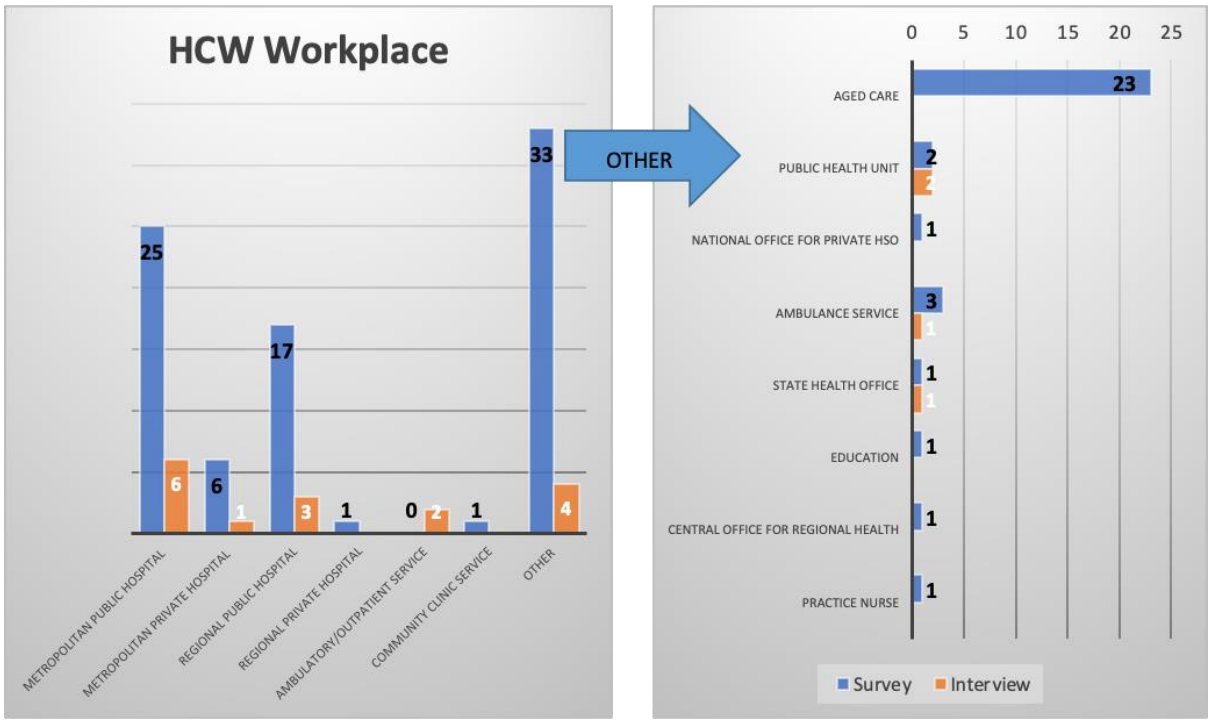


Figure 35. Breakdown of Surveyed HCWs' workplaces.

Introduction

Broadly speaking, healthcare workers and patients in this study reported that using VMS for hand hygiene auditing would be acceptable. However, for them, acceptability came with a range of caveats and considerations to make the approach more, rather than less, acceptable. These caveats were technical and methodological in nature and are defined by the following five interconnected themes (Table 22): 1. *Protecting patient privacy*, 2. *Making HCWs feel safe*, 3. *Open communication,* 4. *The how and when of feedback*, and 5. *Better data, better feedback, better care*. These themes are explored and evidenced next.

Table 22. Themes and subthemes emerging from the Study 3 data.

Theme	Subthemes
Protecting patient privacy	(a) Proximity activation (b) Facial pixilation and blurring (c) Camera positioning; (d) Recording video, not audio (e) Using visual/audio recording-in-progress indicators (f) Patient and HCW control of the VMS
Making HCWs feel safe	(a) Fear of surveillance (b) Fear of making a mistake (c) Fear of embarrassment (d) Fear of punitive consequences (e) Fear of legal consequences
Open communication	(a) Consent

	(b) Clarity surrounding footage retention and deletion (c) Confidentiality (d) Legality and legal issues
The how and when of feedback	(a) Lack of immediate feedback (b) Contextual feedback with VMS data (c) Quality of feedback
Better data, better feedback, better care	(a) Validity and reliability of the data collected (b) Efficacy and efficiency of reviewing the data (c) Rich and contextual data

Theme 1: Protecting Patient Privacy

The contention that using VMS would represent an invasion of a patient's privacy, and would hence be unacceptable to patients, was a barrier to the acceptability of the approach that emerged from the literature review, as well as from HCW responses. To this end the concept of patient privacy and how it could be 'protected' via technical and methodological specifications was a significant theme of acceptability.

The first response of most HCWs to the concept of video-based surveillance is that it would be an invasion of patient privacy, as one participant said:

> *"The immediate idea was actually about the patient's privacy and confidentiality… yeah so that's kind of breaching the confidentiality and privacy of the patient… that was the immediate idea that I got when I first saw this" [FLHCW5].*

Survey respondents were also asked directly whether they believed that the use of such technology would constitute an invasion of patient privacy (Figure 36). Approximately half of auditors (54.8%) and FLHCWs (48.9%) agreed or strongly agreed that the use of a VMS for hand hygiene would constitute an invasion of privacy. In comparison, only around 1 in 4 of surveyed patients (25%) agreed that it was an invasion of privacy.

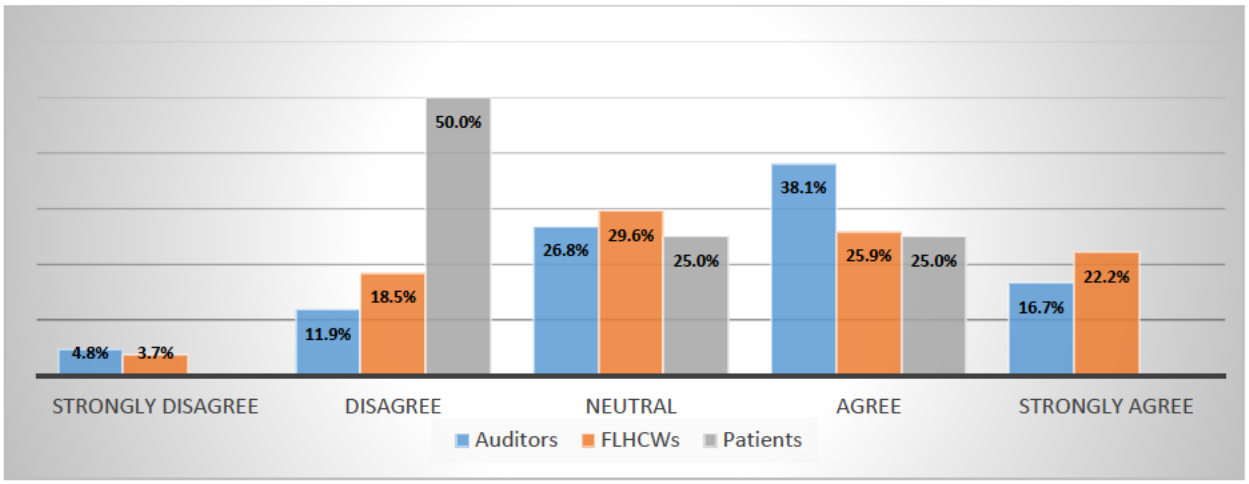


Figure 36. Survey participants' responses to the statement 'the use of a VMS would be an invasion of patient privacy'.

In addition, surveyed HCWs were asked to respond to the statement 'patients would be accepting of the use of VMS for hand hygiene purposes' with the majority of results falling into the neutral (unknown) or disagree/strongly disagree categories (Figure 37), indicating that this sample were either uncertain or doubted that patients would be accepting of the use of a VMS.

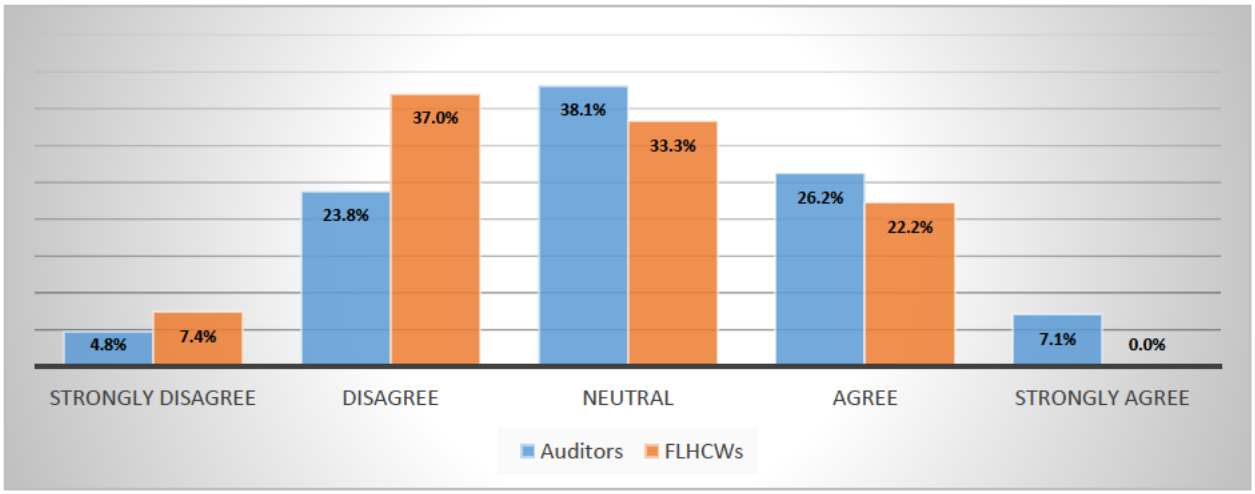


Figure 37. HCW survey respondents' responses to the statement 'Patients would be accepting of the use of VMS for hand hygiene purposes'.

Group Interview HCW participants also indicated that they believed that patients would object to the use of recording technology on the basis that it would be an unacceptable invasion of their privacy. In particular, they highlighted specific, vulnerable patient populations or more intimate care activities where the use of VMS might be deemed particularly problematic. Participants also expressed concerns that the presence of cameras could lead to issues of mistrust and impair relationship building, particularly in patients with mental health issues. Some indicated that cameras

in "*public*" areas were acceptable and possibly essential for "*staff safety*" but that there needed to be limits within the patient zone, as one participant explained:

> *"…I think anywhere that… there's patient privacy at risk… for intimate examinations must be opt in only… and it's got to be opt in for the patient as well as the staff members… definitely got to be opt in for the patients…" [GIDr1].*

HCWs and patients who took part in interviews reported a greater degree of acceptability of VMS although there were a range of views expressed. Only one auditor indicated that they felt a VMS definitely was an invasion of patient privacy while four participants responded that it definitely was not invasion of privacy. The remainder of participants indicated that the use of a VMS would not be an invasion of privacy provided that certain criteria were met. While most HCW participants stated that they themselves did not believe that a VMS would be an invasion of patient privacy, they did offer that "*other people*" would hold such an option and that as such, one that would potentially be a barrier to practical implementation of the approach:

> *"The first thing I can see staff doing… saying... is… you're invading the patient's privacy… so... that's the sort of stuff I think that staff would throw up." [AUDITOR5].*

Those HCWs who stated that they did not consider VMS as an invasion of privacy reported that this was the case for three reasons. First, there was a view expressed that hand hygiene auditors were health professionals who understand confidentiality, as this quote demonstrates:

> *"Yes, I feel like as long as it's health professionals that are watching it for the reason to do the auditing or like yeah… then definitely it would be ok." [FLHCW6].*

Second, using features such as pixilation and rear/overhead placement, patients would resolve their concerns with identifiability, as expressed by the following participant:

> *"It's not really breaching the patient privacy because you can't recognize the patient, and then we all are nurses and then we're not really like concentrating on whether the patient is exposed or like yeah… we don't pay attention on the body parts that are exposed or something… like that." [FLHCW5].*

Third, using such an approach was important for patient care, as one auditor explained:

> *"The level of care that we can validate by video… you know… that's a quality improvement issue." [AUDITOR3].*

Interestingly, one patient expressed a similar perspective:

> *"I believe that if it's um… a… not a mandate, but if it's something that's necessary for the care of the resident. And let's face it, you know… we would hope that infection control is controlled, and if this is part of doing that then I don't think it's an invasion at all, yes… I feel that that doesn't constitute an invasion of a person's privacy actually." [PATIENT4].*

Patients a gave a positive or conditionally positive response to the concept provided there was open and upfront explanation of the process and that it was undertaken with a positive and improvement focused objective. As one explained:

> *"I mean, for me, personally, I'm not too bothered by it, but I do know, some people would have an issue with being recorded at all, but I think for the right reasons, you know, assuming that, obviously, the use of the footage and all that sort of stuff would be regulated… I wouldn't be concerned" [PATIENT3].*

The analysis also examined the acceptability of VMS for hand hygiene relative to direct observation in an attempt to explore if and how responses to this approach differed to that to the use of VMS. None of the eight patients indicated that they thought direct observational hand hygiene auditing was an invasion of privacy. Most gave a firm negative response, indicating that they did not feel that their privacy would be compromised, as one explained:

> *"Wouldn't worry me at all… I believe any medical procedure that is done for the benefit of the patient, or resident is something that one accepts as part and parcel of the care". [PATIENT4].*

The remaining patients indicated that so long as information was provided and consent was obtained that they would not consider direct observation to be an invasion of their privacy. As one patient described:

> *"That would be dependent upon whether you announced to both the patient and the worker what you were there for and why you were there… I mean to me that's… well it's rather a simple issue but it's an issue of obtaining informed consent" [PATIENT1].*

In contrast, a small number of interviewed HCWs stated that direct observational auditing was indeed an invasion of patient privacy, although there were degrees to this stance. One auditor was emphatic as to the invasiveness:

> *"There have been times… I've had to interact with the patient… to explain what's going on and… and… ah… they've been many Moments where I've thought… this patient really doesn't need another person in the room… and… they're not*

> *empowered to say anything and the HCW around them aren't saying "don't come here"… yes there is that pushing into a space where… probably auditing shouldn't be taking place" [AUDITOR 1].*

Six of the interviewed HCWs gave conditional responses to the question of whether direct observation could be an invasion of privacy, for example, if consent was not obtained, or as this participant explained:

> *"….If you have to draw the curtains, say for instance if you're doing patient care, like if you're giving a medication, and you have the curtains open fine for all to see. But if then that auditor steps in behind the curtains with you… to… you know… see what you're doing now, then I think it is an invasion of privacy." [FLHCW3].*

The remainder of the interview participants indicated that they did not feel that direct observational auditing was an invasion of privacy at all, as illustrated by this auditor's remarks:

> *"I don't think patient's mind. I haven't really had any patients that have particularly shown any… being upset by it, and you can usually just say… look I'm auditing, talk to patients… say I'm auditing… You know." [AUDITOR7].*

The rationale was the stated belief that that the HCW performing direct observation was engaged in a legitimate activity, the outcome of which was to ultimately improve the quality and safety of patient care, as another participant noted:

> *"I'd say no in that I'm assuming that the auditor is a health professional who's signed the confidentiality, and therefore, in a way you know that this is something that is taken seriously. So, I think in hospital unfortunately, as a patient, you do feel that there's more people than needs to be sometimes but I don't think it is an invasion of privacy… Hmmm... no, it's not an invasion of privacy, because, you know, it's showing that the system is trying to work" [FLHCW8].*

The participants offered six technical and methodological measures or considerations to protect patient privacy, and which would increase the acceptability of VMS. These were: 1. proximity activation, 2. facial pixilation and blurring, 3. camera positioning, 4. recording video, not audio, 5. using visual/audio recording-in-progress indicators, and 6. patient and HCW control of the VMS.

Proximity activation of cameras

The use of a proximity beacon, meaning cameras record only when the HCW was geographically near, was seen as either somewhat or very important for the majority of survey respondents (Figure 38).

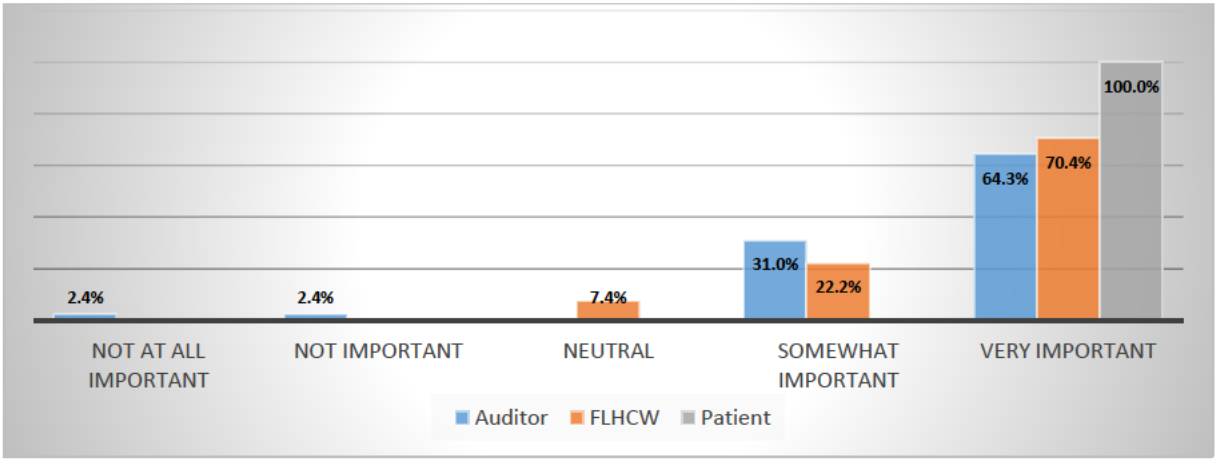


Figure 38. Survey respondents' responses to the importance of the feature 'Cameras only record when the HCW is present'.

Similarly, all 24 interview participants reported this as the most impactful technical feature in terms of acceptability. For some participants the benefits were on a practical level, with the reduction in footage and hence auditing time as an advantage:

> *"I think it saves a lot of data for you guys of having to rewind back. So, I think that would definitely be helpful so you don't have to watch like so many spaces." [FLHCW6].*

Most HCWs reported the primary benefits of the proximity feature as being very reassuring for patients, affording them a greater sense of privacy, comfort, and reassurance when they were alone in their bed spaces/rooms, in particular when sleeping:

> *"Yeah, I think it would make patients feel more comfortable so it's not just, you know… they're having a sleep in their bed and we're leaving them alone…. Like they're not being filmed." [FLHCW1].*

One HCW reported that not only would the use of a proximity beacon make the approach more acceptable to patients, but that this feature also made the process somewhat similar to direct observational auditing. They indicated that they saw this form of data collection not so much an invasion of privacy as a change in privacy as the following comment illustrates:

> *"I mean if the cameras are only activated when someone comes into the room. Then, in terms of privacy, there's somebody in the room anyway so the um… Technically, privacy, hasn't gone out the window, but there's a change in privacy, yeah, yeah." [FLHCW3].*

All patients viewed the proximity beacon feature with favour, reporting it as less intrusive and more focused on the HCW than on them, as one reported:

> *"Yeah… I think it… yeah I think that would improve, improve my acceptability of it… If it only activated. If I could be 100% guaranteed and it only activated… if… when the healthcare worker came into the room." [PATIENT8].*

While some HCWs and patients were accepting of continuous recording in certain circumstances, a proportion found this notion "*a bit disturbing*" [FLHCW7], with one patient, who embraced the idea of proximity activated recording, being nonetheless horrified by the idea of being continuously recorded, further supporting the power of proximity activation as an important feature to enhance acceptability:

> *"The first one [CONTINUOUS RECORDING]… I would HATE to be in a room where I was being filmed all the time… as a patient… at your lowest point. I would hate it. Absolutely!" [PATIENT8].*

Facial blurring or pixilation

Facial blurring or pixilation was reported as another way to protect patient privacy and hence improve the acceptability of the approach. Survey respondents were generally in favour of technology which ensured facial blurring or pixilation, with most indicating that they saw it at somewhat or very important (Figure 39).

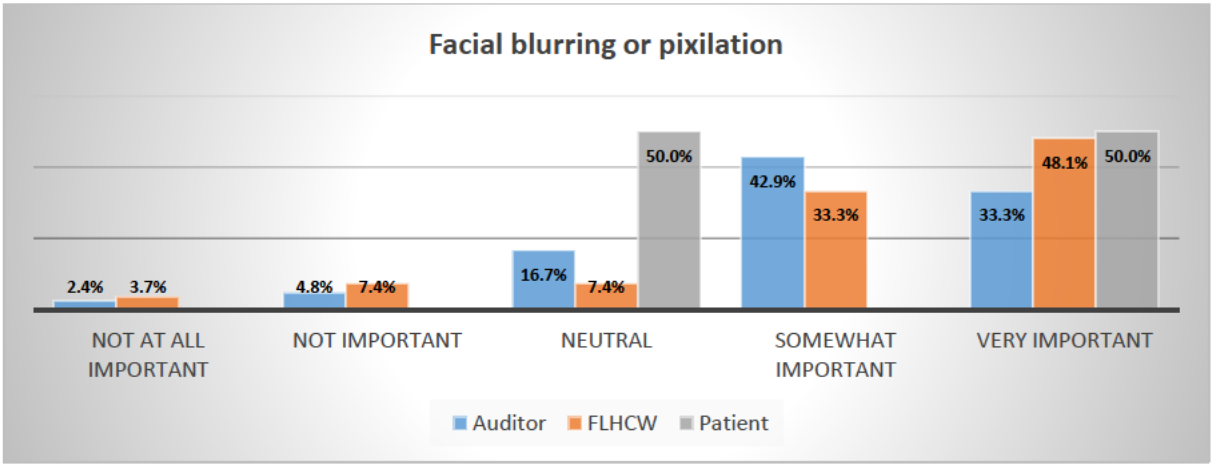


Figure 39. Survey respondents' responses to the importance of the feature 'Facial blurring or pixilation'.

All interview participants were also strongly in favour of this feature, seeing it as a benefit and reassurance for both patients and HCWs. While many indicated that facial pixilation would not render them entirely "*unidentifiable*" it was nonetheless "*more anonymous*" *[FLHCW2]*. When one HCW was shown data with facial pixilation applied they immediately responded:

"Absolutely, I felt much more at ease. But obviously, people would probably still be identifiable by mannerisms and their body shape and size and things like that. But automatically… face pixelation that… definitely… yeah." [FLHCW3].

Most HCW respondents felt that patients would be particularly in favour of this feature, which combined with the use of a proximity beacon, would further take the focus away from patients while still allowing data collection:

"With the pixelated face. I think it's… you know… Not breaching too much privacy but it's also for the study, making sure it's good practice." [FLHCW6].

Similarly, all patients were in favour of facial pixilation reporting that it gave them a greater degree of privacy. One patient even suggested that pixilation would enable the use of footage for other purposes such as education and training before going on to comment:

"Right! So, it will be completely deidentified anyway. Yeah. Yeah. I think that would help people be more comfortable with it." [PATIENT3].

Camera positioning

Camera position was another system feature that was proposed as affording enhanced patient privacy and acceptability. Placement behind or above (as distinct from front or side-on) received a predominantly neutral to somewhat important response, with two out of four (50%) patients rating this feature as somewhat or very important. Similar ratings were observed for auditors (50%) and FLHCWs (overhead 50%, rear 37%) as illustrated in Figure 40 and Figure 41.

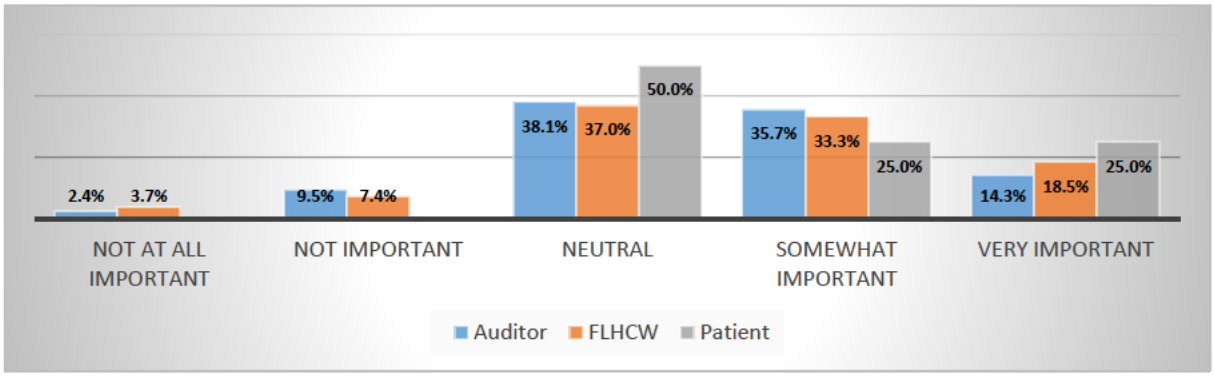


Figure 40. Survey respondents' responses to the importance of the feature 'Cameras placed directly overhead'.

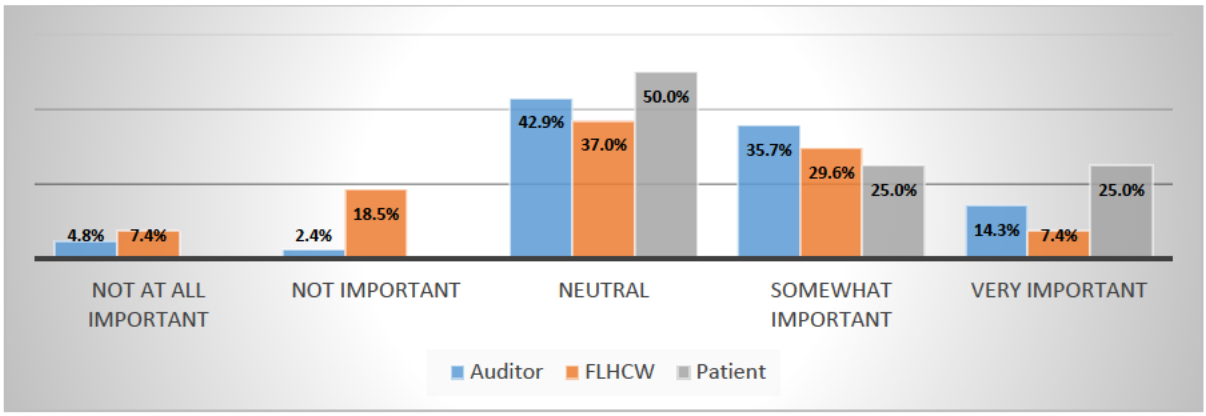


Figure 41. Survey respondents' responses to the importance of the feature 'Cameras placed behind the head of the bed'.

Almost all the interview participants (95.8%), however, expressed a clear preference for rear or overhead positioning of the camera, with only one auditor reporting they had no partiality. The reason for the stronger preference demonstrated by interview participants as compared to survey respondents is unclear. However, it must be noted that interview participants were able to view sample footage which was shared (Figure 42) as compared to the survey respondents who responded to the statements concerning camera position with no other details.

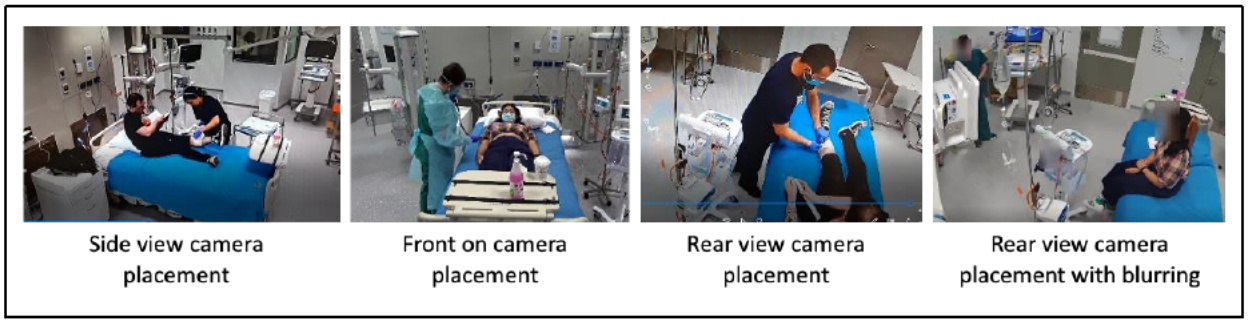


Figure 42. Sample footage demonstrating side, front and rear (+/- facial blurring) camera placement.

Both HCW and patient interview participants expressed that the rear camera view afforded greater privacy, particularly when combined with both facial pixilation and proximity beacon features. The front-on view was considered more invasive and was deemed unlikely to be accepted by patients. The rear view was seen to place the emphasis on the HCW without undue exposure to the patient and still provide sufficient coverage to allow auditing to take place, as these excerpts illustrate:

> *"The head of the bed would probably be an appropriate one and then that way the patient might feel a bit more secure as well because it's not their face right, front and*

centre all the time either. And then obviously if they are having anything done, down below. Again, a bit more privacy. In that respect as well." [FLHCW3].

"Yes, good idea, because you're only getting the back of the patient, which is more private." [PATIENT4].

The above excerpts demonstrate the importance of camera placement in terms of acceptability, with different positions offering different advantages.

Recording Video, but not Audio

Recording video and not audio was reported by the majority of participants to improve acceptability. Variously deemed somewhat or very important by 59.8% of auditors, 70.3% of FLHCWs and 50% of patients and as a neutral feature by a further 18.5-25% of each cohort (Figure 43).

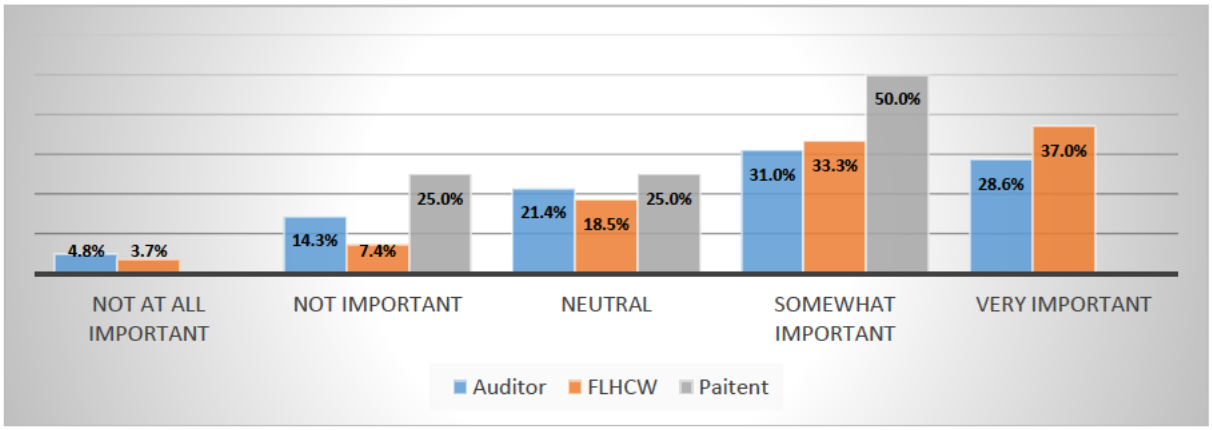


Figure 43. Survey respondents' responses to the importance of the feature 'Not recording audio'.

Group interview HCW participants in Study 2 were very clear as to the importance of recording video without audio as helping to protect patient privacy. As one participant explained, the recording of audio may result in staff not asking or patients not answering particular questions that could incriminate or embarrass and so jeopardise the completeness of the patient history and examination:

"Say... there's... you know a woman with a fever of unknown origin... I'm gonna have to ask her about STI's, PID that kind of stuff... I don't want people to self-censor because there's cameras..." [GIDr1].

Initial responses at interview were somewhat ambivalent with regard to this feature, with only half of all participants initially indicating that they thought an absence of audio recording was important. However, once the rationale for not recording audio, in terms of the potential for "*self-censoring*", was provided along with an assurance that audio was not needed to allow auditing, then all participants agreed that it was a sensible feature of the approach. They indicated that it would

protect both patient and HCW privacy and would in turn improve the acceptability of the approach. As one participant said:

> *"If you have an interaction with a patient and they want to divulge something that's quite personal or something like that... Yeah... Yes, I think that would be... They might feel safer with that one." [FLHCW1].*

Using visual/audio recording-in-progress indicators

Another system feature proposed as beneficial to protect patient privacy and to improve acceptability was using visual or audio indicators that recording was taking place. The presence of a visual indicator was seen as somewhat to very important by most survey respondents, with 52% of auditors, 66.6% of FLHCWs and all patients selecting that response (Figure 44). An audible tone at the commencement of recording was slightly less well supported with 26.1% of auditors, 51.8% of FLHCWs and 50% of patients deeming this a somewhat or very important feature (Figure 45).

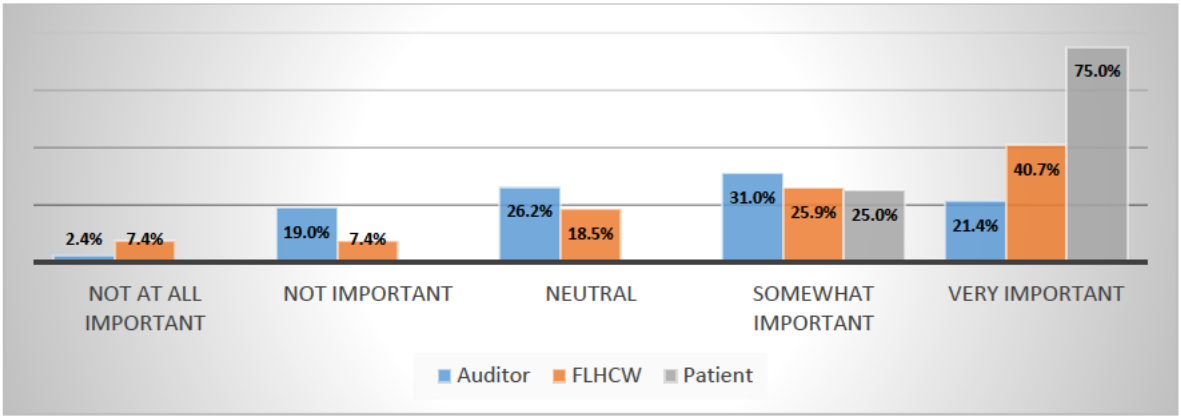


Figure 44. Survey respondents' responses to the importance of the feature 'Warning light/sign when recording is taking place'.

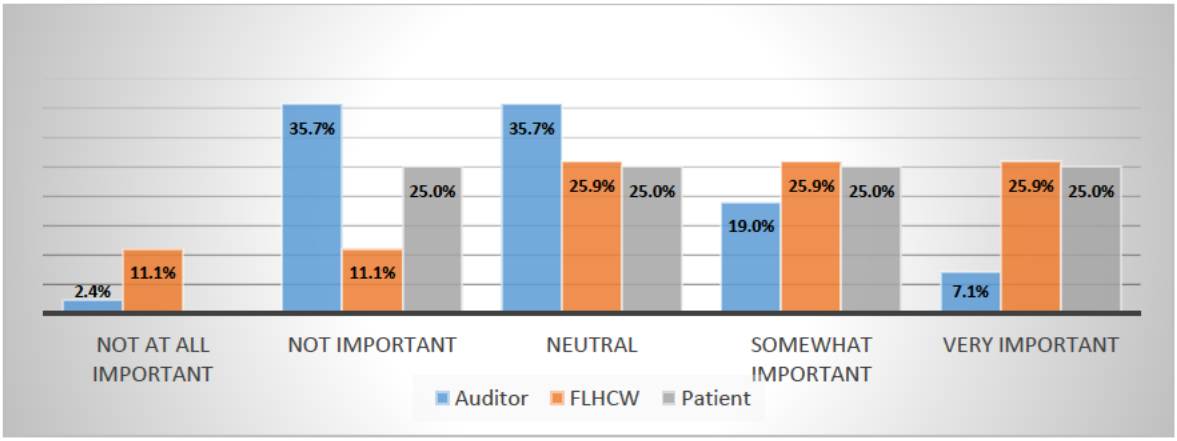


Figure 45. Survey respondents' responses to the importance of the feature 'Audible tone when auditing starts'.

For those participating in interviews the use of a warning light, sign or some form of active visual indicator was seen as important by 19 out of 24 participants. While the intent behind this feature was to reassure patients by allowing them to know when recording was or was not taking place, there were two patients that questioned its benefit. One indicated that they did not feel they would be able to trust this feature:

> *"Yeah, but in the back of my mind. I would always not really trust it. Especially when I know I'm going to be actively recorded I'd always be on edge." [PATIENT6].*

Another patient felt that while there may be some benefit to a form of indicator of camera activation, by and large it would go unnoticed:

> *"I think, like, under the stress of being in the hospital, you probably wouldn't even notice that… they'd notice it the first time, probably the first time only, it wouldn't be harmful to have… but I don't know that anyone would even notice it after the first 10 minutes" [PATIENT5].*

Similarly, one of the auditors indicated that they did not see a lot of point in such a feature, noting that it would likely be ignored in much the way the radiation lights were in theatre or medical imaging:

> *"I'll give you examples of this because we have to by law have lights that are in place and… and audible sounds in the OT when the XR's are being emitted and everyone just ignores them." [AUDITOR5].*

Another point raised in relation to the inclusion of a recording in progress indicator was the possibility of this serving as a prompt or reminder for HCWs to perform hand hygiene. Some participants saw this as advantageous in that it may have a form of ongoing Hawthorne Effect:

> *"Sure… that would be good… that actually… that actually then encouraging and then prompting and reminding people to do the right thing" [FLHCW5].*

Others saw this as a disadvantage, suggesting that a recording indicator would be analogous to the physical presence of a human auditor meaning that the validity of the data could be impacted. As one participant noted:

> *"In terms of healthcare workers, I feel like it might actually skew the data a bit more… because if the nurse recognizes that very camera is filming… that it would bring their attention to it… Then they'd be thinking Oh hand hygiene… Hand hygiene." [FLHCW3].*

Most participants, however, saw the use of a recording indicator as primarily a form of reassurance for patients that, in conjunction with a proximity beacon, would illustrate that recording was not be taking place at certain times. This might be, for example, when a HCW was not present, or not at all if the patient had declined to participate or had requested the camera to be turned off at any point. As one auditor remarked:

> *"Um… that would be really important to somebody who's worried about their privacy… because then they could see… because we've said "oh no, we're turning it off", or "the system won't be working for you because of"… whatever …" then um, they will be able to see that it's not on, or that there's a red light showing that it's not working or whatever it is that you do" [AUDITOR1].*

Most patients appeared to agree with this stance, whilst not reporting that they believed the feature was highly importance, the attitude seemed to be more along the lines of something that this was useful to have, a feature that provided a little more reassurance that things were working as promised:

> *"Yeah, yeah, that might be useful. So that they're, I guess, is a solid… yeah… Just to confirm that what's been said is how it's actually applying that you can kind of find some way of knowing when it's recording or not" [PATIENT3].*

Patient and HCW control of the VMS

Giving patients and HCW the options to control cameras and recording was proposed as a measure to protect patient privacy and increase the acceptability of VMS. The majority of survey respondents indicated that they believed that it was somewhat or very important for there to be the option to turn the cameras off at any time during patient care, with 65.7%, 92.6% and 100% of auditors, FLHCWs and patients respectively (Figure 46).

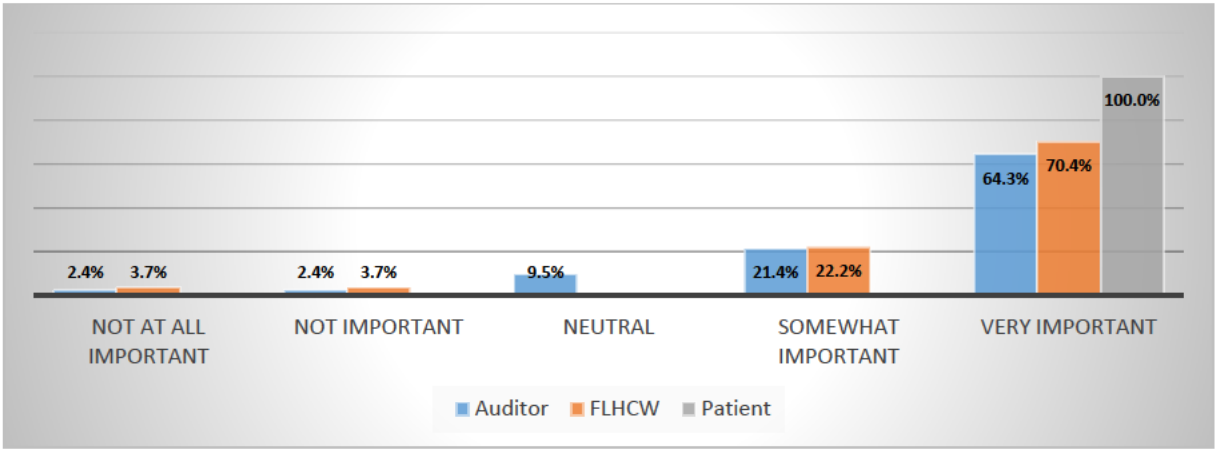


Figure 46. Survey respondents' responses to the importance of the feature 'There is the option to turn the camera off at any time during patient care'.

The question as to who, patients or HCWs, should be able to turn the cameras off was less clear cut. Whereas the overwhelming majority of participants reported the ability of patients to turn cameras off was somewhat or very important (Figure 47), HCWs being able to turn off cameras was rated as less important, except for FLHCWs of whom 44.4% reported this to be very important (Figure 48).

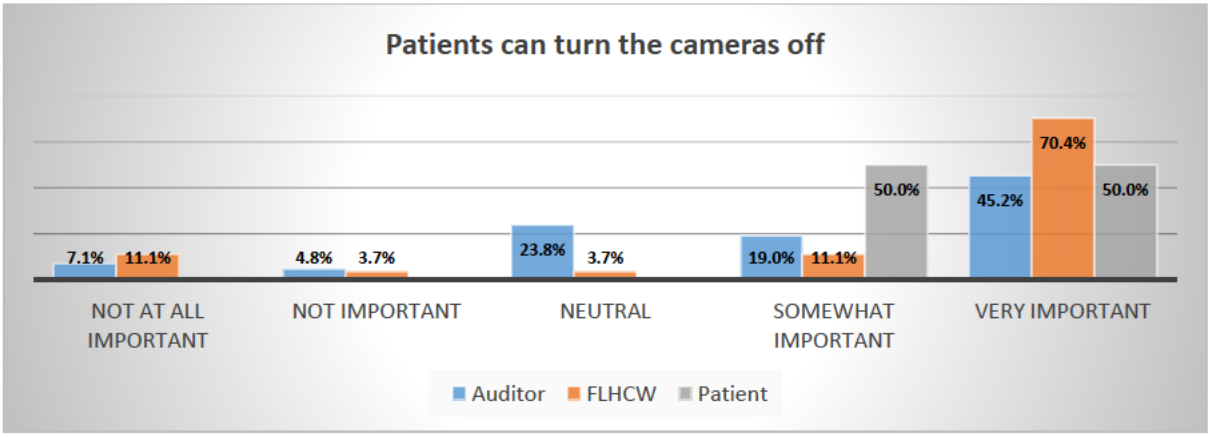


Figure 47. Survey respondents' responses to the importance of the feature 'Patients can turn the camera off'.

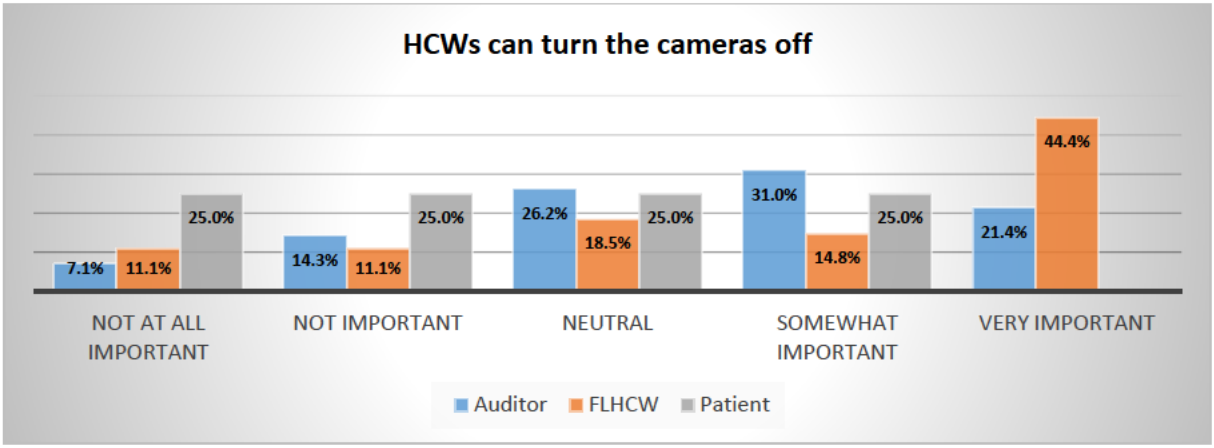


Figure 48. Survey respondents' responses to the importance of the feature 'HCWs can turn the cameras off'.

The majority of interview participants reported that patients should be able to control the cameras. HCWs advocated for this on the basis that the ability to turn the cameras off when desired may provide reassurance and a feeling of control for patients:

> *"Yeah, I think they would, they'd feel like they've got control over it a bit more." [FLHCW1].*

One FLHCW expanded on this thought, suggesting that being able to turn the cameras off, particularly during sensitive or intimate procedures would be helpful for patients:

> *"Yeah sort of like... Oh we're doing this right now so we're going to turn this off or whatever... like you were putting in a catheter or doing whatever. I think that would be helpful in some occasions, especially for yeah people who are concerned about privacy." [FLHCW2].*

Seven out of eight patients supported the ability for them to have control over the operation of the camera, with the eighth patient participant stressing that they did not feel there would be a need for this feature personally, but that they understood why others may feel this way:

> *"I couldn't see any reason for doing that but I perhaps... think that... the patient may want to do that... have that extra security of personal... ah... personal information if you like... that's not the word I'm really looking for, but have some control... personal control... Yes." [PATIENT4].*

In terms of the potential for HCWs to turn the cameras off, as with the survey responses, the interview results were less homogenous. While a small number of the HCWs reported that it was important for them to turn the camera off when they judged it to be appropriate, there were also a some who said otherwise. As one auditor remarked:

> *"Staff turning the camera off (laughs) oh that's a bit of a worry isn't it… I suppose if they… it's… ah… that would be their perception if there's a privacy issue I suppose and not the patient's perception and so yeah... so I think it's more beneficial to have the patient be able to turn that camera off." [AUDITOR4].*

Several interviewed HCW participants held similar concerns, questioning the impact that this might have on the validity of the data if segments were missing, potentially important segments such as invasive procedures where hand hygiene was pivotal. As one stated:

> *"Whether people could actually... turn it off and... and I kind of think… sure that… that's... a worthy thing to do… however it… then starts taking away from the validity of your observation because well... what happened in those events... were… what Moments are we not capturing… and are they important." [AUDITOR1].*

Other respondents linked the ability of HCWs to turn the cameras off to current curtain closing behaviour, which, was suggested to occur when HCWs did not want to be observed rather than strictly being for the benefit of patient privacy. As one said:

> *"I think it will probably maybe provide a bit more comfort for the patient… Um… But then in terms of auditing hand hygiene, it makes it… I guess a bit tricky… it's the same like going back to the curtains, pulling the curtains. So, you know, I mean, really… doing procedures like that, that's kind of really when you need the auditing too, isn't it?" [FLHCW3].*

Most patients were somewhat ambivalent about HCWs being able to deactivate cameras however one did express concerns about this as an option suggesting that HCWs could deactivate recording for their own purposes, as expressed by this patient:

> *"But the only thought about them turning it off is, you know, what if they do it to do something that they shouldn't be doing and then part of the evidence isn't there... and so the questions come in. So, that is a hard one… I don't know." [PATIENT5].*

Summary

Protecting patient privacy was a major theme to the acceptability of VMS for hand hygiene. Use of proximity activation measures, facial pixilation and blurring, optional camera positioning, recording video and not audio, visual/audio recording-in-progress indicators and giving patients and HCWs control of the VMS were important measures identified by participants to help protect patient privacy and thus improve acceptability. Conversely, the absence of these measures reduced the acceptability of VMS for hand hygiene.

Theme 2: Making Healthcare Workers Feel Safe

Interconnected with patient privacy was the importance of making healthcare workers feel safe with VMS. In this theme were an interrelated array of fears expressed by HCW participants which acted as barriers to the acceptability of the approach. Measures to address and resolve these fears, and hence to make HCWs feel safe, were proposed by participants, which in turn acted to enhance acceptability. In total, there were five predominant barriers to making HCW feel safe, all of which were expressed by participants as fears.

Fear of surveillance

The fear of surveillance was a problem for some participants in this study, but not others. As illustrated in Figure 49, when survey respondents were asked if they would be unhappy about having their practice recorded, their responses were spread across the 5-point Likert scale.

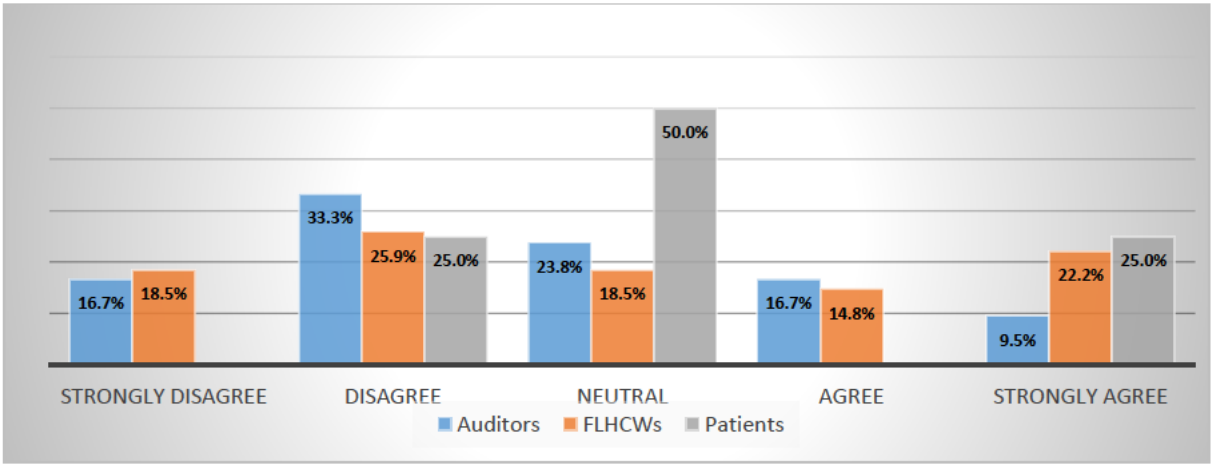


Figure 49. Survey respondents' responses to the statements 'I would be unhappy having my practice recorded' (HCWs) or 'Staff would be unhappy having their practice recorded' (Patients).

HCWs at survey were also asked to indicate whether the use of a VMS would cause them to feel as if 'Big Brother' was watching (Figure 50). While the responses by auditors were relatively split (38.1% disagree/strongly disagree vs 42.9% agree/strongly agree), FLHCWs views tended to be more in agreement with the statement (22.2% disagree/strongly disagree vs 59.2% agree/strongly agree).

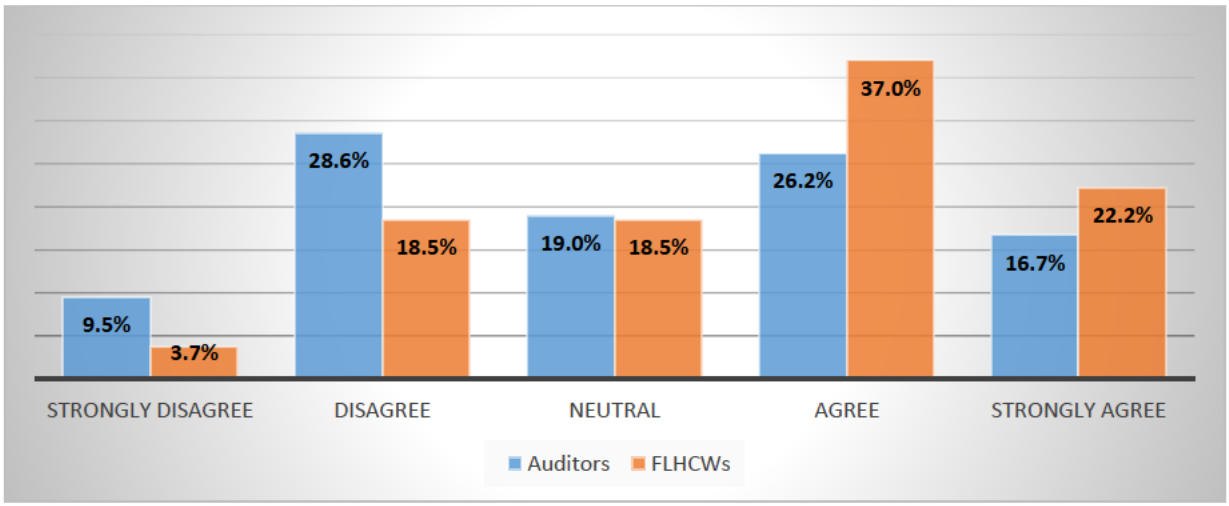


Figure 50. HCW survey respondents' responses to the statement 'The use of the VMS would cause me to feel like 'Big Brother' is watching'.

Similar themes emerged at interview, participants stated that cameras were an invasion of their privacy and reported feelings of 'Big Brother' scrutiny as a distinct disadvantage of the approach, as well as a potential barrier to acceptability:

> *"It's a bit "Big Brotherish" to some people and definitely a lot of people will see that as invasion of their privacy... not necessarily the patient's privacy it could just be the HCWs." [AUDITOR1].*

Another HCW participant expressed a similar view, as expressed by this excerpt:

> *"No... I just think it's a privacy issue... I just feel a lot of staff would feel... It's more of a privacy issue, and possibly that, you know, do we really need to have a camera there all the time watching us doing it" [FLHCW5].*

On the other hand, a number of participants probed the validity of HCWs concerns for their privacy, asking what could HCWs possibility doing in the clinical area what would be considered particularly private for themselves. The follow excepts illustrate this subtheme and the perceived fallacy of the privacy argument:

> *"...you'd think if you're not doing the wrong thing, then why does that matter anyway. You know." [FLHCW2].*

> *"What would you be doing in a hospital... (laughs) that would be a problem being filmed for... But Cameras... Cameras are only... not good for you if you're doing the wrong thing, and if you're often intentionally doing the wrong thing..." [PATIENT5].*

Fear of making a mistake

For HCWs, associated with the concept of 'Big Brother' and being watched, were concerns relating to their practice being recorded causing performance anxiety, leading them to "*second guess" [AUDITOR5]* themselves and/or make a mistake. This in turn could lead to feelings of being judged and worries that their practice would be found lacking. For example, as one participant explained:

> *"The first thing I can see staff saying is… "I'm more likely to make a mistake if I feel like Big Brother's watching me…" so… that's the sort of stuff I think that staff would throw up." [AUDITOR5].*

Another concurred, but went on to opine that the fear was more likely than not unfounded and further, to reinforce the notion that ideally staff should welcome feedback:

> *"I think they'd be scared that their practice is lacking, perhaps, when in actual fact it's probably not. And you know the other things are things that we will be working with them on and you would want to, as a healthcare worker you really ultimately want to know if you're putting your patient, at risk." [AUDITOR7].*

A further HCW participant agreed and also highlighted that there was no need to be fearful of mistakes but to treat them as a chance to improve:

> *"I don't think anyone should be fearful for example of doing the wrong thing in hand hygiene because at the end of the day, you… they're doing it [auditing] for a reason. That's why they've called you out on it, and told you what you need to do better, which is, in nursing practice… you need to continue to grow and learn." [FLHCW6].*

However, it was argued that HCWs can operate from a perfectionist paradigm and feel ashamed of making a mistake, rather than seeing it as an opportunity to improve:

> *"…I think a lot of us… we're very, a lot of us are very sort of perfectionist, and Type A personalities and to be caught up, making a mistake... is sort of a bit shameful and… A loss of face it's sort of… really… Yeah, and I think we have quite high standards and we're hardest on ourselves actually, a lot of the time. So, you know that needs to be managed… making people feel very much that it's okay and it's very common." [FLHCW7].*

One patient, who had a background in law enforcement, indicated that they could understand these feelings on the basis of their experience as a trainer but went on to endorse the need to move beyond the fear and turn the process into a learning opportunity:

> *"When people feel like they're being targeted as a staff member… And I know at the start of it [being recorded] they all feel so horrible because like… they're so scared of mucking up, but, like, you keep saying "It's not to get you into trouble. It's just so you can do things better… it's just how you learn", you know, "it's why you do training"… so if you can kind of remind people, or reinforce that the only reason you're doing these things is to better them." [PAITENT5].*

Fear of embarrassment

Fear of making a mistake was interconnected with fears of embarrassment which formed the third subtheme. Participants reported that they, or more commonly that they believed that *"other staff"*, would have a fear of being embarrassed or "*loosing face"* as a consequence of less than perfect practice being detected via the video-based system. Associated with this were concerns about having their practice judged and held up as wanting by peers or colleagues, particularly senior staff. One participant related their experience as a junior clinician along with the hope that things had changed, but with a feeling that fears surrounding the issue still lingered within the culture of healthcare:

> *"The old… you know… shaming you and embarrassing you in front of everybody and yeah, and some of them still treat the next generation like that which is wrong… So, you know, there's still young doctors and older doctors who have had that sort of very negative experience about so called feedback… so, we really just need to change it. We just need to do it the right way and make that the norm." [FLHCW7].*

In addition to embarrassment with regard to actual or potential mistakes, a small number of HCWs, as well as patients, expressed mortification that cameras might capture potentially embarrassing personal behaviours. Notwithstanding that those viewing the footage would be HCWs with an understanding of confidentiality, there was a certain degree of potential humiliation associated with the possibility:

> *"It could catch me, you know, scratching (laughs) picking my wedge, you know, things like that. So yeah, it's a bit confronting you know… you might catch someone… having a bit of a quiet scratch or… you know what I mean?" [FLHCW3].*

> *"When you're in your own room you… you know might want to fart or… you know pass wind or you know." [PATIENT8].*

HCWs raised concerns that using VMS for hand hygiene could cause them to feel like they could not be trusted, as one participant suggested:

> *"It's… like there's a fear of being watched and it's kind of... that you don't trust me. And I guess that comes to the heart of it that you know, we're all clinicians, we all… are there for the right reasons we hope… I think it's about a bit of trust. It's kind of that fear of… "Oh but you don't trust me" that… that… "you don't value me or trust me as a professional." I… I don't feel that, I think… we maybe just need to figure how do you move from that fear, which is a natural idea, to actually clinical outcomes from hospital acquired infections and hand hygiene which we know is not done" [FLHCW8].*

Fear of punitive consequences

Fears that use of VMS for hand hygiene would bring punitive consequences was a subtheme that emerged most strongly from the group interview data where participants expressed concern that the identification of incorrect practice and the way in which this was managed could be used in a deliberately punitive manner or could result in a disciplinary response as the following conversation illustrates:

> *"If people aren't feeling safe then it's taken seriously and they work out how to make it safe so that it doesn't… like ah... I'm thinking of something... of one unit that we have in this district in particular where... um... there… there is somebody who works there who I know would use this…" [GINse1].*
>
> *"For evil for rather than good?" [GIDr1].*
>
> *"Yeah" [GINse1].*

Group Interview participants also raised concerns about staff feeling "*stressed and hammered"*, potential "*secret police"* behaviour in terms of data collection and the need to:

> *"…be careful how you approach it in terms of tailoring it so that you don't... have a distressed junior doctor being more stressed… because they're already really… really stressed and a whole bunch of them already kill themselves every year so yeah… don't 'stacks on' with that" [GIDr1].*

In the survey, it was FLHCWs who were more likely to agree that they were worried that recorded mistakes could be used as evidence against them compared to auditors (59.2% agreed/strongly agreed vs 35.7% of auditors) (Figure 51). It may be that those conducting audits possess greater knowledge about correct practice and hence may be less inclined to err, and as a result have less fear of the consequences of mistakes than those who were the subject of auditing.

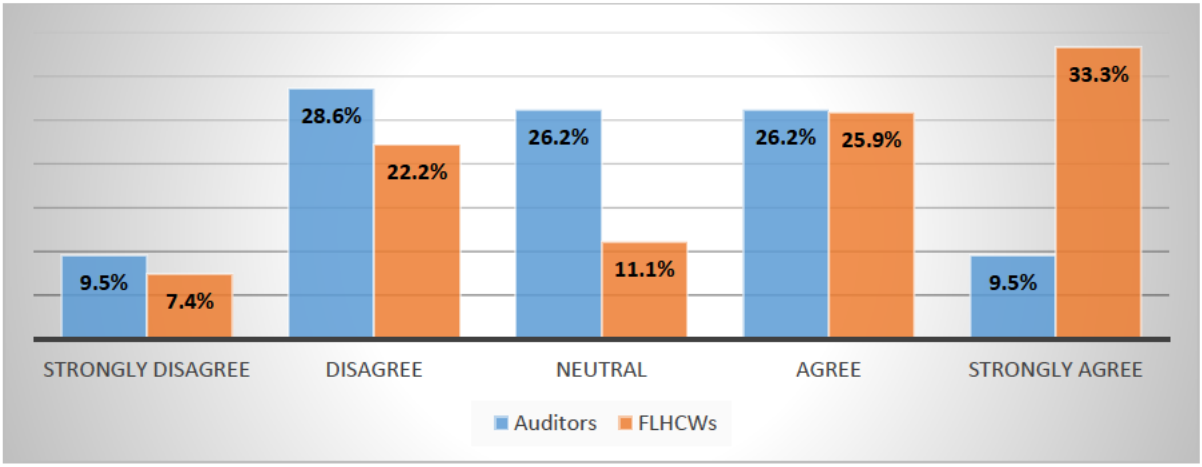


Figure 51. HCW survey respondents' responses to the statement 'I would worry that any hand hygiene mistakes I make in the footage could be used in evidence against me'.

The fear of punitive consequences as a result of any mistake detected via VMS was also made clear by interview participants use of words and phrases such as *"reprimand" [FLHCW4], "getting in to trouble" [FLHCW2]*, being *"called out" [FLHCW1], "incriminated" [AUDITOR6]* along with *"judgement", "repercussions"* and *"punishment" [FLHCW3],* as well as the expression of concerns that they would *"lose their job" [FLHCW5].* The following except encapsulates the fear of negative outcomes expressed by participants:

> *"You'd be... you know... have some black marks against your name in the personnel file or the... to go against you if you were going for promotion or a job or worse... you know. Reporting to authorities for disciplinary action yeah or... who knows... it... depends on the nature of the breach. I mean, think that missing a step in your hand hygiene wouldn't be an offence that'd be serious enough to cause you to be struck off the register. But I do think that there is that sort of underlying fear of retribution and punishment." [FLHCW7].*

However, some participants did express the belief that if one wasn't doing anything wrong, 'why would you worry?'. The following participant went even further:

> *"If that was your immediate reaction like... If I'm afraid I'm gonna get into trouble... I think you'd have to have an awareness that you're probably already doing something that needed to be looked at anyway. Yeah." [FLHCW2].*

Fear of legal consequences

Many, but not all, HCW participants described their concern for legal consequence arising from the use of VMS. For example, some questioned whether data from VMS would end be subject to FOI:

> *"I would think that you wouldn't want a patient to be able to use that against you? So you know, I, people when they're sick, have the strangest views on things and don't always… And, you know, I would think that you wouldn't want it to come under Freedom of Information… unless it was a criminal offence I would think." [AUDITOR6].*

Others expressed that having such data available has advantages in terms of providing evidence or a record of what happened:

> *"Yeah… and that's… it goes both ways… there could be situations where the footage could be used for the staff member's benefit as well, because patients often do things and say things that are not true." [AUDITOR7].*

Participants expressed curiosity and concerns as to the legal standing and consequences of the use of VMS, which are jurisdictional matters.

Comparison between Responses to Direct Observation and VMS

Participants were asked about the use of VMS for hand hygiene relative to direct observational auditing. At survey, HCWs were asked to respond to a series of statements relating to their reactions to having their practice audited via direct observation. The survey responses in Table 23 indicate that the majority of participants reported that they had a preference for the auditor to be open about what they were doing (60 – 61.8% agree or strongly agree), did not 'mind' their practice being audited (91.2 – 92% agree or strongly agree) and disagreed that being watched by the auditor made them feel worried that they would make a mistake (62 – 70.6% disagree or strongly disagree). Most disagreed or strongly disagreed with the statements 'Being audited makes me uncomfortable' (60 – 64.7%) and 'I find auditing to be intrusive' (70 – 70.6%). However, somewhat confusingly, when asked to respond to the statement 'I would prefer not to know auditing was taking place', 70% of auditors were neutral (48%) or agreed/strongly agreed (22%). The results for FLHCWs were lower with 58.9% of this population either neutral (35.5%) or agreeing (20.6%) with the statement, perhaps suggesting an auditor preference for covert auditing.

Table 23. Auditor and FLHCWs' responses to direct observation auditing statements.

Statement	Pop.	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I don't mind my practice bring observed by the auditor.	Auditor	0% (0)	2% (1)	6% (3)	44% (22)	48% (24)
	FLHCW	0% (0)	2.9% (1)	5.9% (2)	26.5% (9)	64.7% (22)
I prefer it when the auditor is open about their auditing.	Auditor	0% (0)	10% (5)	30% (15)	32% (16)	28% (14)
	FLHCW	2.9% (1)	5.9% (2)	29.4% (10)	32.4% (11)	29.4% (10)
	Auditor	30% (15)	30% (15)	22% (11)	18% (9)	0% (0)

Being audited makes me uncomfortable.	FLHCW	26.5% (9)	38.2% (13)	20.6% (7)	8.8% (3)	5.9% (2)
I find auditing to be intrusive.	Auditor	32% (16)	38% (19)	14% (7)	12% (6)	2% (1)
	FLHCW	38.2% (13)	32.4% (11)	26.5% (9)	2.9% (1)	0% (0)
I worry that I will make a mistake and "get into trouble" while I am being watched.	Auditor	28% (14)	34% (17)	22% (11)	12% (6)	2% (1)
	FLHCW	20.6% (7)	50% (17)	8.8% (3)	14.7% (5)	5.9% (2)
I would prefer not to know auditing was taking place.	Auditor	8% (4)	22% (11)	48% (24)	20% (10)	2% (1)
	FLHCW	8.8% (3)	35.3% (12)	35.3% (12)	20.6% (7)	0% (0)

In contrast to survey respondents who had indicated that, by and large, they did not mind having their practice audited via direct observation and, on the whole, did not feel uncomfortable in the presence of the auditor, all bar one HCW interview participant described a variety of negative emotions in connection with direct observation hand hygiene auditing. Words and phrases such as *"awkward" [FLHCW1]*, *"anxious" [FLHCW6]*, *"stressed" [FLHCW3], "intimidated" [FLHCW2]*, *"judged and nervous" [FLHCW5]*, *"pressured and uncomfortable" [FLHCW8],* as well as *"embarrassing and nerve wracking" [FLHCW7]* were used. A HCW who participated in interview and had experienced direct observation auditing, reported their negative emotional response to the practice as follows:

> *"Of course, it is making me feeling nervous, because even if I know I'm doing the right thing. Like when someone is closely monitoring you… like you obviously want to do the right thing that… but yeah. It kind of makes me nervous… When I'm just thinking as long as I'm doing the right thing it should ok. So yeah… like people can be judgmental of you and then oh, like that kind of embarrassment because you've been a HCW for... so many years... like "she can't even do this right" … like that feeling... so you are always scared of that feeling at work" [FLHCW5].*

The analysis revealed that participants' perceptions of and responses to direct observation were in many respects consistent with those that they anticipated towards VMS.

> *"I think they get more nervous when we're there with doing face to face audits… like they will get nervous and like always I think they end up doing inappropriate Moments of hand hygiene every 2 seconds..." [AUDITOR2].*

There were a range of measures suggested by the participants that could increase the acceptability of VMS. This would be achieved not only by protecting patient privacy, as was described in the first theme, but also by making HCWs feel safe and, as will be discussed next in the exploration of the third theme, via open communication.

Theme 3: Open Communication

The third theme 'open communication' illustrates that the acceptability of VMS for hand hygiene to those subject to the use it depends on their comprehension of both the processes involved and the rationale behind those processes. That is, to know how the system would work and why. This could be achieved by having informed consent, providing education and/or engaging in consultation for HCWs and patients alike. Central to this theme were participants' strong needs and assurances that the process would be open and upfront, as illustrated by these excerpts:

> *"It's just about transparency and understanding… people having a broader understanding… as long as there's some kind of clear protocol" [FLHCW7].*

> *"Just transparency when it comes to it, so obviously just up front, just talking about everything… like a guarantee that it's being used for the reason stated" [PATIENT6].*

The participants identified several considerations upon which acceptability, relative to open communication, depends, namely: 1. *Consent*, 2. *Footage retention and deletion*, 3. *Confidentiality*, and 4. *Legality and legal issues*.

Consent

Participants expressed the need for consent for patients who would be subject to the use of VMS. Gaining consent was seen as a way of achieving '*open communication'* about the approach, particularly for patients. Many participants suggested individual consent would be needed for the use of VMS, however, HCWs expressed reluctance to obtain this due to the lack of time among other reasons:

> *"It's (obtaining consent) also a conversation that you've got to have… plus you've got to deactivate the camera… you just don't have time…" [GIDr1].*

At survey, patients were asked to respond to several statements about consent. All participants indicated that consent was required and disagreed that recording could take place without consent. All patients also indicated that individual consent was required for every admission. In addition, they agreed or strongly agreed that signage should be prominently displayed in patient rooms and that information should be provided as to the operation of the auditing system and how patients could opt out (Table 24 and Table 25).

Table 24. Patient survey respondents' responses to the statement 'Do you believe that patient consent is required to conduct hand hygiene auditing using novel VMS?'.

Statement	Yes	No

Do you believe that patient consent is required to conduct hand hygiene auditing using novel VMS?	4	0

Table 25. Patient survey respondents' responses to the statements concerning consent to use VMS for hand hygiene auditing.

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Video recording can occur without the need to obtain individual patient consent.	2	2			
Signs explaining that auditing may take place and information about how to opt out should be prominently displayed in the patient room.				2	2
Consent for video recording should be obtained only once and will apply to any/all future admissions.	1	1		2	
Individual consent should be obtained on every admission to the facility.				2	2

At interview many participants reported consent as mitigating privacy concerns for patients:

> *"I feel like if you asked for consent, it should be fine… as long as they provide consent… it wouldn't be an invasion of privacy and gives them [patients] reassurance and the reason why" [FLHCW6].*

A verbal consent process was favoured by some participants, but not others. One concern raised was that verbal consent would become a "telling" rather than an "asking" one, that is, patients would be told that recording was happening rather than being asked if they agreed with the process. This is connected with the view reported by the majority of participants that the use of VMS for hand hygiene auditing should be "opt-out" rather than "opt-in", placing the onus on the patient to decline to participate:

> *"You have to opt out rather than opting in, or something like that. So, it's more like the default is that it's [filming] done. You've got the option to opt out." [PATIENT3].*

Another issue with verbal consent was the importance of documentation, that is, that the consent to participation, or conversely the decision to 'opt out' was documented, even if it was provided verbally:

> *"I think it's probably um… can be verbal consent, but it needs to be documented. When that happened, you know." [AUDITOR6].*

One patient was quite detailed with what they believed was needed for the information and consent process, detailing both method and format of the consent process that they recommended:

> *"I would recommend using… you know… an easy read sort of format where you know you've got pictures, pictures of cameras and staff, you've got pictures of patients doing things so there could be no or at least minimal risk of people misinterpreting. This is a camera, this is what it does, and these are the times… Dot… dot… dot when these things are happening, when we will be recording. And you should be able to put that… I think… in one relatively clear page with the question at the bottom… "do you consent to this happening… name… patient reference number, date, signature and… with minimal amount of text on the page." [PATIENT1]*

What was clear was that consent is an essential aspect of any approach that involved the use of video-based monitoring in healthcare. One patient also reinforced the need for consent to undertake auditing, no matter if it was via direct observation or using a VMS:

> *"Patients should have to consent to one or both methods" [patient free text survey response]*

Some participants also raised the point that clarification was needed as to the management of VMS in the context of patients who were unable to consent owing to confusion, incapacity or lack of English language proficiency:

> *"Plus, what do you do if you've got a patient that can't give consent... who's under the guardianship act… who's demented or delirious or whatever… you know if English is a second language... mmmm… yeah... I like the core concept of it… but I think that there's ethical… concerns about it…" [GIDr1].*

For these participants, giving consent would aid in safeguarding that there was open communication with regard to the approach and that this in turn would aid in rendering the use of a VMS more acceptable.

Clarity of footage retention and deletion

As a part of their giving consent, it was very important to participants for them to have an understanding of the process of footage retention and subsequent deletion. Having an assurance that recordings would not be kept on file and potentially used for other purposes was seen as vital to some. These views were held by HCWs and patients alike, particularly in terms of clarity and

understanding as to how the footage would be managed, stored, and importantly, deleted. Most participants supported the use of footage for ongoing education purposes. They indicated that all concerned should have a full understanding of the process and 'rules' regarding the duration of footage retention:

> *"So I would want to know… if you've looked at that, and there's nothing of any value beside auditing, the Moments and that's been recorded, then that can just be deleted. You know, because if it's all gonna be gone within a week... or 48 hours... depending on how quickly people get to review the data… so I think that would be reassuring because it's not going to be kept for a long period" [AUDITOR7].*

These responses were not confined to HCWs, patients also indicated the need for reassurance that the footage would not be retained long-term, as illustrated by the following:

> *"I think it'd be nice to be told it's being deleted so that you're not worried about … is it going to be sitting around for years on end" [PATIENT2].*

If however the footage was to be retained beyond the specified period, or even retained permanently for ongoing education purposes, then stakeholders needed to be informed and their consent sought:

> *"Obviously having footage is fantastic for that and you should use it to say to someone look just here you need to do this or that, but the moment you take any recording or… or save any documentation, the patient either needs to be offered the opportunity to have a copy, or to just give consent." [PATIENT5].*

The participants understanding of this, in many instances, reflected their knowledge and understanding of policy for CCTV recordings of public areas in healthcare and the standardised requirement of rolling deletion after a set period of time. As one auditor who used camera-based surveillance in public areas, such as hallways, explained:

> *"It just automatically deletes after 14 days" [AUDITOR2].*

Another auditor however was certain that within their jurisdiction deletion of footage recorded via a VMS would not be permitted:

> *"Once it's recorded… it's… it's a healthcare record… and it doesn't matter what you say... I mean you say "oh we can delete this" … no you can't… It's a healthcare record and it has to start appearing as such so I think it's going to… it has a lot of problems… you can't just say… "oh well will... after the audit we'll delete... we'll do the*

> *assessment and delete it" I don't think you can… as soon as somebody has some problem… a medical problem and they know that that was on… the lawyers will be calling for it and when it doesn't appear... that will be the moment… I don't want to be the healthcare executive having to defend that!" [AUDITOR1].*

While the 'rules' may differ from state to state, the status of the recordings and the requirement for their retention and deletion was certainly something that concerned HCWs and patients and moreover was something that would need to be clearly outlined and communicated to all stakeholders prior to the implementation of a video-based monitoring system.

Confidentiality

Associated with retention and deletion of the footage was the need for clarity as to the confidentiality of the data and openness as to who could see and have access to the recorded footage. Both HCWs and patients were concerned that there would not be a "*free for all" [Auditor6]* in terms of viewing recordings, that only the appropriate individuals had access and then for the 'right' reasons:

> *"Just the people that are accessing it I guess too. You wouldn't want a free for all for everybody. I mean… I honestly don't really mind for myself, but I do think that if there was a situation where… you know, let's say, you know, they have to get all the clothes off and you're lying there naked, even if it's a non-sexual nature, I'd be fine with it… As long as I was, 100% sure that that footage was staying where it was meant to be, I don't care if a billion people looked at it, as long as it wasn't being used for the wrong reasons and in today's society. That's the big problem." [PATIENT5].*

For HCWs their concerns were more related to worries about their peers or managers gaining unauthorised access the footage. Participants indicated that they needed to clearly understand the process of access to the footage as the following comment indicates:

> *"What would be the ability for the auditors to see the film footage. So that would be the other thing like… who has access to it? People up the food chain can't swoop in and seize it? That would be something to think about… The governance." [FLHCW7].*

In addition, they emphasised that only designated individuals should have access and permission to access the VMS data to protect HCW privacy as this discussion between participants suggests:

> *"The people who were trained to do so [view the footage in order to audit] and also have… signed like a… documentation or a code of conduct... or whatever to… I don't*

know… to show them that you understand that any footage that you see obviously you can't really keep it or share it with other people" [GINse3].

"Yeah... you don't want your colleagues talking about you like…"oh that person" you know – 'cause you don't half the ward dissecting a video... going "Oh my God… bloody Jane"" [GINse2].

All participants reported the importance of confidentiality and clear communication regarding this as a relevant factor in the acceptability of VMS for hand hygiene auditing.

Legality and legal issues

Participants and HCWs expressed the importance of understanding the legality of VMS. Some expressed concerns and fears in relation to the legal status of VMS data. Questions arose as to whether the footage could be subpoenaed in legal proceedings and where the footage stood in terms of freedom of information (FOI) status:

"I would think that you wouldn't want a patient to be able to use that against you? So you know… people when they're sick, have the strangest views on things and don't always… And, you know, I would think that you wouldn't want it to come under Freedom of Information ….unless it was a criminal offence I would think." [AUDITOR6].

Participants also postulated that the use of rear positioning combined with facial pixilation may mean that patients were not identifiable and that this in turn may change the status of the footage in terms of legal or FOI classification. Several participants pointed out however that rather than being used 'against' HCWs, recorded footage could in fact exonerate them:

"Yeah…. And that's … it goes both ways… there could be situations where the footage could be used for the staff member's benefit as well, because patients often do things and say things that are not true." [AUDITOR7].

The legality of VMS and associated legal issues are clearly dependent on jurisdictional legislative mandate and constraints that participants expected to be educated about and to have knowledge of, highlighting the importance of the final subtheme of information and education.

Information and education to improve acceptability

Participants noted the importance of public promotion and education campaigns to inform the community of VMS auditing and improving acceptability. The combination of signage and education for healthcare worker and patients was important, particularly when it came to the differences between opt-in and opt-out consent for individuals. Participants also indicated that form

written information should be provided to patients, as well as utilising internal *"hospital television" [AUDITOR4]* or similar communication modes:

> *"I suppose when it's [a VMS] first introduced and there's a big sort of campaign to make the um… community aware that this happens in this facility… um I think you... they need to have the opportunity first to and then… it… probably will become standard… however" [AUDITOR4].*

> *"I just think, just some… maybe just some open information to say this is what we'd be doing. And if you've got a problem with it, just to approach whoever they can approach to say, Listen, I'm not comfortable with this… you know." [PATIENT5].*

Group interview participants spoke of the need to "sell" the concept of VMS for hand hygiene in a careful manner. Suggestions were made that the process should be explained as part of the overall educational and improvement approach for the health service:

> *"It's more talked about as our… education... you know… part of our education plan... is to give you personalized… but also… we have to audit... and I'm sorry… you work here we need to audit you but we're going to tie our audit into personalized education for you" [GINse1].*

The HCW interview participants described the importance of ensuring lots of staff 'buy in' through education and demonstrations, building rapport and relationships with all involved, via being open, honest and acknowledging fears, as well as providing solid proof of the benefits of the approach. It was also seen as essential to ensure that the system worked as promised, in particular features such as the proximity beacons and facial pixilation. In addition, some form or guarantee as to the non-punitive management of any recorded noncompliance or other poor practice:

> *"I just think... um... lots of involvement with the staff... you know whether they… they watch and they… maybe critique it and... suggest an improvement... you know sometimes it's… it'll become the norm because people will think... you know… there is no way that I cannot do this… I have… you know… this HAS to be done." [AUDITOR3].*

> *"So, I think they probably have to be some kind of like… like sort of… staff forums or something so people can raise their concerns and maybe can come up with a policy that sort of works for them or whatever and then people feel like they've been, you know, had their opinions heard about it." [FLHCW2].*

Patients at interview also highlighted the need for the process to be upfront and transparent and saw it as essential that there was good communication or education regarding the rationale behind

the approach. They called for proof that the system was used for its intended purpose and for good. They also felt that if there was evidence that their treating clinicians supported the system, patients would be more likely to do so:

> *"I think it would be a package of things… but patients will also be influenced not only by their family but their medical practitioner, their nurse, the people around them… yes… most patients will be heavily influenced in their confidence of something by whether their treating professionals have confidence" [PATIENT1].*

For the participants in this study, introducing VMS for hand hygiene slowly and carefully would aid in its acceptability.

Theme 4: The 'How' and 'When' of Feedback

How and when feedback about hand hygiene compliance using VMS data would be given was another significant consideration when it came to its acceptability to healthcare workers and patients. There were three subthemes that enlightened this, 1. Loss of immediate feedback with VMS, 2. Contextual Feedback with VMS data, and 3. Quality of feedback.

Loss of immediate feedback

Many HCW participants expressed concerns that, unlike direct observational auditing, the use of video-based modalities would lead to a lack of immediate feedback on practice and compliance:

> *"With traditional hand hygiene audit I can give feedback and it's immediate feedback and that's the most important thing because you stop the process and say "I'm auditing" here you're not following the 5 Moments you need to stop and re-think this because it's actually unsafe… now by delaying with the video it's... this is never gonna happen" [AUDITOR1].*

However, upon reflection and further discussion, most HCWs acknowledged, that the provision of feedback in the clinical setting was actually quite rare as the following participant described:

> *"I don't think you get, I've never… I've never… when I've had hand hygiene auditors… I don't get immediate feedback either… because it'll come up later like… Oh the emergency department had 70% hand hygiene or whatever and everyone needs to do better, and whatever it is but you don't get actual direct feedback on your practice" [FLHCW2].*

When the provision of feedback in relation to direct observation was further discussed with interview participants, auditors saw direct observational auditing as an ideal opportunity to educate, provide feedback and improve hand hygiene practice. To have a *"finger on the pulse" [AUDITOR5]* and ultimately decrease the risk of HCAI and improve patient safety:

> *"…from my perspective, doing auditing has given me the opportunity to actually intervene and say "hey… this isn't working… and this is where we could make an improvement"" [AUDITOR1].*

At survey, auditors were asked about their feedback experiences and practices in terms of frequency. The results are interesting in that, while 72% of auditors reported that they gave feedback often or always, the receipt of feedback was recorded as often or always by only 22% when they themselves were being audited. In addition, only 26.4% of FLHCW respondents reported the receipt of feedback often or always. Most auditors and FLHCWs reported that they received feedback either rarely or sometimes and disturbingly 14.7% of FLHCW respondents indicated that they never received feedback (Table 26). These results suggest that while auditors reported that they provided feedback 'often or always' this may not be the case, and indeed does not seem to be reflected in their own experiences nor those of frontline healthcare workers.

Table 26. Survey Respondents – frequency of feedback provision by auditors and receipt of feedback by auditors and FLHCWs in relation to direct observational hand hygiene auditing.

Frequency of feedback	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
Given by Auditor when conducting direct observation.	0% (0)	6% (3)	22% (11)	46% (23)	26% (13)
Received by Auditor when they are the subject of direct observational auditing.	6% (3)	34% (17)	38% (19)	16% (8)	6% (3)
Received by FLHCW when they are the subject of direct observational auditing.	14.7% (5)	29.4% (10)	29.4% (10)	17.6% (6)	8.8% (3)

At interview, auditors were also asked if they provided feedback and all responded that they did, however the nature and quality of the feedback varied. One auditor, for example, indicated that;

> *"I try and give feedback to most people but sometimes they go off and do other things… but if you can give it to them…" [AUDITOR6].*

Similarly other auditor respondents described how they would "try" to give feedback but that it "*wasn't always possible*" [AUDITOR4] or described the use of delayed feedback to managers, in person or via emailed report. For one auditor, tackling noncompliance was clearly something that they were not comfortable with and they admitted that feedback mainly consisted of:

> *"If are they doing like…. Correct Moments then I sort of give them the thumbs up…" [AUDITOR8].*

> *FLHCWs were also asked if they could recall having received feedback on their hand hygiene practice. Of the eight FLHCW interview participants, two indicated that they had never personally experienced either direct observational hand hygiene auditing nor subsequent feedback and a further three indicated that they had experience direct observational auditing but had not received any individual or personal feedback. The remaining three FLHCWs indicated that they received feedback 'sometimes' and that it was either quite broad and unit-based in nature or rather superficial and non-specific: '"I'd say it's sometimes… but it's nothing lengthy… it's just "Oh cool. You did great" that's it… [FLHCW6].*

The survey results (Table 27) would appear to indicate that FLHCWs wished to receive feedback on their hand hygiene practices and that doing so would not make them feel 'stressed' or 'picked on'. Nor would receiving feedback about poor compliance result in a loss of confidence.

Table 27. HCW survey respondents' responses to statements regarding their feelings about and responses to feedback related to direct observational hand hygiene auditing.

Statement	Pop.	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I appreciate it when the auditor interacts with me and offers me feedback about my practice.	Auditor	0% (0)	0% (0)	6% (3)	58% (29)	36% (18)
	FLHCW	2.9% (1)	0% (0)	2.9% (1)	35.3% (12)	58.8% (20)
	Auditor	34% (17)	56% (28)	8% (16)	0% (0)	2% (1)

I prefer the auditor not to offer me feedback.	FLHCW	44.1% (15)	44.1% (15)	11.8% (4)	0% (0)	0% (0)
Receiving feedback makes me feel stressed and nervous.	Auditor	24% (12)	38% (17)	28% (14)	10% (5)	0% (0)
	FLHCW	26.5% (9)	41.2% (14)	17.6% (6)	11.8% (4)	2.9% (1)
Receiving feedback makes me feel like I am being picked on.	Auditor	36% (18)	46% (23)	14% (7)	2% (1)	2% (1)
	FLHCW	41.2% (14)	41.2% (14)	14.7% (5)	2.9% (1)	0% (0)
I worry that I will make a mistake and "get into trouble" while I am being watched.	Auditor	28% (14)	34% (17)	22% (11)	12% (6)	2% (1)
	FLHCW	20.6% (7)	50% (17)	8.8% (3)	14.7% (5)	5.9% (2)
Receiving feedback about poor compliance can result in loss of confidence for HCWs.	Auditor	10% (5)	40% (20)	32% (16)	16% (8)	2% (1)
	FLHCW	11.8% (4)	52.9% (18)	29.4% (10)	5.9% (2)	0% (0)

Interview participants were asked to discuss how receiving feedback made them feel or to conjecture as to how they thought it would make them feel if they had not had feedback on their hand hygiene compliance. Responses varied; several participants indicated that they were happy or would be happy to have feedback, although given the paucity of feedback reported at interview many of the responses were theoretical and hence it would be informative to see if it changed in the context of actual rather than theoretical feedback. For example, one interview participant indicated that while they thought that they would like to receive feedback (this not having been the case) they acknowledged that not all HCWs would want the feedback nor would respond positively when it was given:

> *"I think I'd prefer it, but then there's some people who don't take that well, as well so I think it's you know it's… I guess it's a bit individual. But yeah, I would prefer that… if I'm doing something wrong, I'd rather someone actually say something, than just let me keep on doing it… yeah." [FLHCW2].*

Other participants indicated that they felt that that receiving feedback was, or could be a negative experience, although there was some qualification in terms of these experiences, in that their reactions could be dependent on the nature and context of the feedback provided:

> *"You feel bad and you start to sort of question, you know, have you been doing the right thing, could you be doing things better and things like that… um yeah." [FLHCW3].*

Surveyed auditors were asked to reflect upon and report any negative responses they had received as a result of providing feedback (Table 28). Few (16%) indicated that they had never had a negative response to the provision of feedback. The remainder reported a variety of negative behaviours ranging from having been yelled at through to negative comments, gestures such as eye-rolling and defensive body language.

Table 28. Auditor survey respondents reported negative responses to the provision of feedback related to hand hygiene compliance.

Responses	**Proportion (Count)**
Never had a negative response to feedback	16% (8)
Being ignored	36% (36)
Defensive body language	52% (26)
Gestures (e.g. eye rolling)	44% (22)
Negative comments (e.g. Insults)	40% (20)
Being yelled at	4% (2)
Having a door shut or curtains drawn in their face to prevent auditing	28% (14)
Other (surveyed free responses): • "Not being taken seriously" • "Denial and excuses" • "Hearing but not listening" • "Rationalisation of noncompliance/excuse making"	8% (4)

Auditors at survey and interview expressed divergent views regarding the frequency of the feedback they gave. Some reported this to be enjoyable and part of the job, but others stated that they thought those whose practice they audited found the process uncomfortable and an unwanted intrusion. They also reported various negative responses to the process of direct observation and the associated provision of feedback. At interview, auditors discussed their perceptions of how recipients felt and how they behaved when feedback was given. While a few reported that most HCW's *"take it pretty well" [AUDITOR7],* words and phrases such as *"resistance" [AUDITOR4]*, *"feel threatened" [AUDITOR3]*, *"a bit defensive" [AUDITOR6]*, *"embarrassed" [AUDITOR8]* and that it was seen as *"a bit 'Big Brother' because you're following them around" [AUDITOR7]* were also evident in their responses. As one auditor explained:

> *"They don't want feedback in the middle of clinical day... or in front of the patient... like... you have to have to those conversations after… yeah and then they can't remember what they did or didn't do" [AUDITOR2].*

There may be multiple reasons for the lack of feedback being provided during or after direct observational hand hygiene auditing. One of these was flagged by one of the group interview participants, a current hand hygiene auditor, who admitted that they may not always approach the individual HCW, but rather might report concerns to an educator or other key staff member in a general and non-identifying manner. When asked why, they responded:

> *"It's not my role… I don't want to overstepping… most especially just say if I was… one junior nurses that was trained to audit… but then the nurse that's in there is senior… it… it makes me feel quite uncomfortable to be in that kind of position to let them know... um… it really depends on who's taking the audits… what their role is and how they're going to approach… um… who was in the room at that time…" [GINse3].*

Further reflection by participants even began to question the value of feedback in the midst of the clinical milieu. Participants spoke of the busyness of a clinical day and how: *"…the cortisol's flying… you… you don't even feel like you're real… you're just doing things" [GINse2].* In such a situation, they argued, it was hard to practice mindfully and to recognize your own actions if called to reflect upon them. They spoke of not being consciously aware and of being unable to recognize actions that they had recently undertaken, describing feedback in this context as:

> *"Some abstract concept of... 5 minutes ago I saw you… not wash your hands before whatever… it's abstract." [GINse1].*

While recognizing the importance of learning and improving practice and of ensuring maximal patient safety, participants opined that this was not realistic in the midst of a busy clinical shift. The following quotation is particularly telling:

> *"You can't comfortably learn something if you know your house is burning down… on wards for example things are moving so fast once you get pulled out of that engine... unless someone's gonna help you... which unfortunately they can't help you... nothing happens... so then when you're having this moment... your head's going… Oh crikey… I'm trying to enjoy this moment but all I can think about is… the 4 patients that nothing's happening with…"[GINse2].*

The initial responses regarding the lack of immediate feedback inherent in the use of VMS for hand hygiene auditing was that this would mean a reduction in the acceptability of the approach. Upon reflection, however, participants recognised the potential to use the output data to provide individual and contextualised feedback as will be discussed next.

Contextual feedback with VMS data

Many participants suggested benefits and possibilities inherent in using the VMS footage to provide feedback. Feedback they suggested could be given at an appropriate time and place so that participants could have the capacity to fully reflect on their practice which they would be able to visualise and contextualise. This could be given privately, one on one or, if appropriate, in a group setting:

> *"Watching back real time footage of what you do is... is vital... I though... really like the idea of being able to do it in groups where we can all learn from each other... look at it as a group and sort of people can say "oh yeah but I was doing this because of this" and kind of work out our practices and why we do it like that..." [GINse1].*

The question was put to the survey respondents with the following statement: 'Being able to review the footage of my hand hygiene practice with an auditor would be useful for my training and learning'. The significant majority of HCWs indicated that they agreed or strongly agreed with this statement (Figure 52).

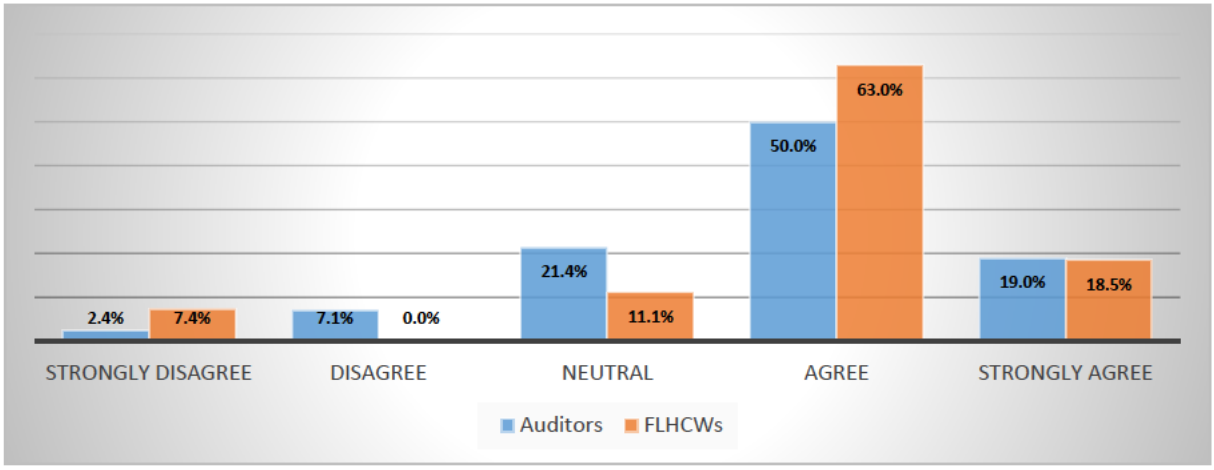


Figure 52. HCW survey respondents' responses to the statement 'Being able to review the footage of my hand hygiene practice would be useful for my training and learning'.

The potential for feedback utilising recorded footage was also raised with interview participants who, by and large, were favourably disposed to the concept. All auditors and 7 of 8 FLHCWs indicated that they, personally, would want to see footage of their own practice and have a

chance to review and discuss any issues identified. The dissenting HCWs indicated that they would "*not need*" *[FLHCW5]* to see the footage as they would believe what the auditor said and would strive to modify their behaviour accordingly. Those in favour of utilising recorded to provide feedback could clearly see advantages to the approach:

> *"I think staff would like the feedback, they would want to see the footage I suppose, it would help put it in… in a context, in context, yes." [FLHCW4].*

Auditors, in particular, could also see the potential to provide education and feedback on multiple aspects of patient care, ultimately improving the quality and safety of the clinical interaction for both patients and staff:

> *"I think that it would provide you with opportunity to give feedback to the staff on other things… like PPE usage… Um… ah… even… even stuff like your physical movement around the room… like if you were… how do you sequence your examination… how do you be most efficient? You could give… staff feedback on ergonomics… you know… "hey wow... worried when I saw you do this, I'm really worried about your back! Here's the video footage of it… this is what I'm concerned about, this is what I'm providing you feedback on"" [AUDITOR5].*

While interview participants anticipated fear and reluctance associated with the receiving, and indeed even the giving, of feedback associated with the use of a VMS, this was in fact very similar to the responses relating to the giving and receiving of feedback in the context of direct observational auditing. While there is also clearly a fear associated with the idea of a video-based monitoring system to record and provide feedback on clinical practice, the emotional reaction to the concept appears similar to that in response to direct observational auditing, with similar language used to describe both. Thus, it is important to consider that a large part of the issue relating to the interconnection between the acceptability of VMS for hand hygiene and the provision of feedback, may relate more to the process of feedback than to the method of data collection. Additionally, feedback via video appears to be an option that many participants would be willing to undertake, hence improving the utility and ultimately, acceptability of the use of VMS for hand hygiene auditing. What was clear, however, was that the method and quality of feedback was also an important factor in relation to the acceptability of VMS for hand hygiene auditing.

Quality of feedback

Factors that could enhance the acceptability of feedback associated with the use of VMS for hand hygiene auditing were identified. Group interview participants stressed that it was important that any issues which were detected be addressed directly with the individual HCW

rather than going to their manager or supervisor as a primary response. This was to both maintain confidentiality and to avoid potential loss of face, as well as address concerns about punitive uses of the data:

> *"It comes to you first as a first line, as the first line of being told is the person who did it and they get the opportunity to... a right of reply" [GINse1].*

> *"Yes… I would appreciate to be pulled aside and coached through that…" [GINse2].*

> *"…but also given a chance to say why you did it… and whether you actually... like something went wrong or actually "I had no idea that I did that" or you know any of that stuff." [GINse1].*

Interview participants were also asked to consider the more practical details of feedback using recorded footage. That is, what the process should be in order to maximise the acceptability of the approach. Often a hypothetical scenario was used to prompt discussion as to feedback preferences. For example, the researcher might pose the question:

> *"If I was reviewing the footage and I noticed that you put in an dressed a wound and the aseptic technique was very poor, what should I do... who should I go to in the first instance?" [example of interview question]*

Some participants were able to immediately articulate their preferred feedback option while others required a list of ideas or suggestions to prompt discussion. This included options such as confidential one-to-one feedback with the hand hygiene auditor, feedback with or from the educator, or with or from the manager. Another possibility was involving others with feedback, such as the educator or manager, only with permission of the staff member, with the caveat that there could be involvement of others if the staff member refused to engage with feedback or improvement activities. Frontline HCWs all indicated that their preference was for the auditor to approach them directly in the first instance. This ties in with previously expressed preferences for maintaining confidentiality and limiting the number of individuals who are exposed to the footage and by extension, who have knowledge of any noncompliance.

> *"I think I'm the kind of person that would prefer someone to come to me and just say "Oh look I was reviewing the footage. And can I can I talk to you about this and make time to talk through it?" I might say actually, I wouldn't mind having a look at the video. But not so much because I wouldn't believe it, I think it just helps to sometimes… you don't even realize what you're doing… Yes… so that's definitely me, I'm very happy to just be approached in that way." [FLHCW8].*

The response by auditors differed in that only three out of eight interviewed auditors indicated their preference to give feedback directly to the HCW, although most auditors indicated that if their own practice was being audited that they would prefer that the approach came to them directly.

All frontline HCWs, while expressing a preference for the matter of their hand hygiene practice to be raised directly one-to-one with them, also indicated that it was acceptable, with their permission, to involve an educator in the process, particularly if additional support or an improvement plan was required. Four of eight auditors also indicated that they believed that seeking permission to involve others in a feedback or improvement process was a good way to proceed:

> *"And maybe like the education team in the department, like if this person needs to … re-do their aseptic non touch technique for cannulation or whatever... Yeah... I think that would be reasonable, and then they can come up with a plan of, you know, we need to re-do this or … whatever it is… yeah." [FLHCW2].*

In contrast, four auditors indicated that they would prefer to provide feedback to the HCW's manager rather than directly to the HCW themselves:

> *"Straight through to the manager... it's about the reporting role… it's important that the manager is the one that is managing behaviour… if the manager's there you would maybe go and talk to the manager and then you'd make a decision about who was going to address it with the person." [AUDITOR3].*

These responses were in opposition to the expressed preferences of FLHCWs as well as those of several auditors who were quite clear that managers should not be involved as a first line response as the following comment indicates:

> *"I feel like, yes. Yeah, I think, personally I would feel like if the discussion was had with educational or managerial staff first… I feel like that would be a bit of… behind the back, kind of like underhanded things… I would rather know myself first." [FLHCW3].*

It is possible to conjecture that a reluctance to give one-to-one feedback related to a lack of comfort or confidence in taking on this role or is reflective of previous poor experiences relating to the provision of feedback.

Several participants suggested that the individual HCWs should be given the option as to the feedback process, that is they could elect to have the feedback one-to-one from the auditor or for the information to be communicated with or via their educator or manager:

> *"And um… if people have a particular preference, because it's less confronting for some people, they might say, well, please come through my manager, and maybe through the management discussions which they're supposed to talk through… that might be the way."[FLHCW8].*

The majority of participants agreed, however, that it was acceptable to involve others such as managers or educators without consent if the HCW refused to engage in the feedback and/or remedial improvement actions.

> *"If it's that first stage, then you've kind of got the opportunity to engage and keep it, keep it… kind of keep it low key, but if you kind of refuse and don't acknowledge that perhaps you've got an issue… that needs to be addressed, they need to know that there could be more actions taken." [AUDITOR7].*

A further caveat as to the involvement of others was the need to ensure that the process was outlined well in advance, that is, prior to the instigation of any VMS, it was made clear how the feedback process would work. This, participants explained, would need to include what the options for feedback were, who would be involved and what the consequences for non-engagement would be, as on auditor succinctly explained:

> *"Yeah, so they wouldn't want it to be a surprise that suddenly someone's turning up and saying, we've seen it on the footage… this is what we've seen. Whereas I think if people were informed about it…and they knew that it was just a one-on-one kind of conversation, it's not going any further at this point, you just have to do whatever the remedial action is." [AUDITOR7].*

However, while supporting the use of recorded to footage to provide feedback, participants were at pains to point out the importance of quality feedback which was safe and supportive. Language surrounding this concept included the need for feedback to be structured, constructive, positive and no-blame. It also needed to be provided by someone who was appropriately qualified, skilled and confident in the process, and who was able to turn the experience into a positive learning activity. Confidentiality needed to be assured and there needed to be clear and defined limits as to who could see the footage. The following excerpt summarises the overall response to the concept, as well as illustrating the interconnectedness of the making HCWs feel safe and the feedback themes:

> *"As long as that is turned into a learning opportunity, I think it can be really beneficial. If those infection control people aren't already trained in how to give constructive feedback then they will need to be… [laughs] that is super important… And very much the… rather than it being… "oh hah hah we caught you out!"… You*

> *know, like, what was going on there when you know? So, I think, you know, just trying to find out what the … the context and the bigger picture as to what, what led to that sort of breaching infection control? Because, yeah, there are probably things in the system… potentially a lot of things and how can we make that easier for you? Yeah… I mean… people are much more likely to learn and change behaviours if they're in a safe and constructive and supportive environment. So that's, if that's your aim in this which I'm sure it is… to help people learn and improve. Yeah, you have to make it safe for the staff" [FLHCW7].*

Although, as noted in Theme 2 and Theme 3, a guarantee that footage would not be kept was also important, it was generally held that if poor practice was identified then it was acceptable to temporarily retain the footage and to instigate feedback and remedial action. It was seen as important however that, provided the HCW engaged with the process, the footage was deleted once the proscribed action was complete:

> *"Yes... yes... I think once the issues, you know, the feedbacks given the… the issues been addressed. Yes... because otherwise staff are going to get you know suspicious." [FLHCW4].*

Ensuring that feedback relating to hand hygiene practice captured with a VMS was given in a confidential and skilled manner and furthermore, that this entire process be openly and clearly communicated at the outset, was another way in which the acceptability of the approach could be enhanced. The provision of quality feedback could also assist HCWs to more accurately reflect upon their practice, improve it if needed and ultimately provide better care.

Theme 5: Better Data, Better Feedback, Better Care

The fifth and final interconnected theme with respect to the acceptability of VMS was 'Better data, better feedback, better care'. This theme underpins the view that data collected via a VMS would be more valid and reliable than data collected using direct observation. The data output from a VMS would be more reflective of practice occurring the majority of time when direct observational auditing was not taking place. Quality feedback would allow HCWs to recognise, reflect upon and improve their practice and in turn would have the potential to improve the quality and safety of healthcare. Inherent to this was an essential tension between the desire for privacy and freedom from surveillance and that of getting better data in order to improve quality of and safety in healthcare.

Validity and reliability of the data collected

HCW Participants in all phases of Study 3 data collection expressed a view that hand hygiene compliance data collected via direct observation was not a reliable or valid reflection of the practice in the setting when not being observed. Focus group participants, for example, expressed concern that, based upon their experiences with direct observation, the physical presence of an auditor affected their behaviour, and that as a result the compliance which was recorded would not be realistically representative of typical practice, as is illustrated in the following conversation thread:

> *"Yeah... I don't mind... the only thing is that I think people "up their game" when they can see..." [GIDr1].*
>
> *"Yeah it's not authentic..." [GINse2].*
>
> *"...Someone watching... yeah" [GIDr1].*
>
> *"I see someone with a board... I just would..." [GINse1].*
>
> *"You think about it more..." [GIDr1].*
>
> *"...yeah... it's at the front of your head" [GINse2].*

Most HCW survey respondents agreed or strongly agreed that they were more aware of their hand hygiene practice if they realised that auditing was taking place (Figure 53). However, when asked to respond to the statement, 'My hand hygiene practice remains the same, regardless of the presence of the auditor', auditors were more likely to agree or strongly agree (76%) with the statement as compared to FLHCWs (54.1%) (Figure 54).

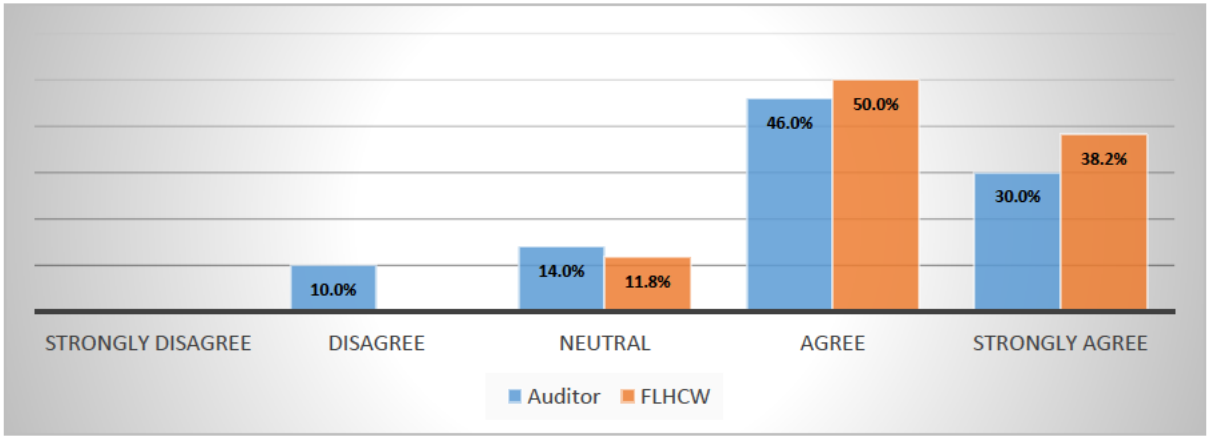


Figure 53. HCW survey respondents' responses to the statement 'If I realize hand hygiene auditing is taking place, I become more aware of my hand hygiene'.

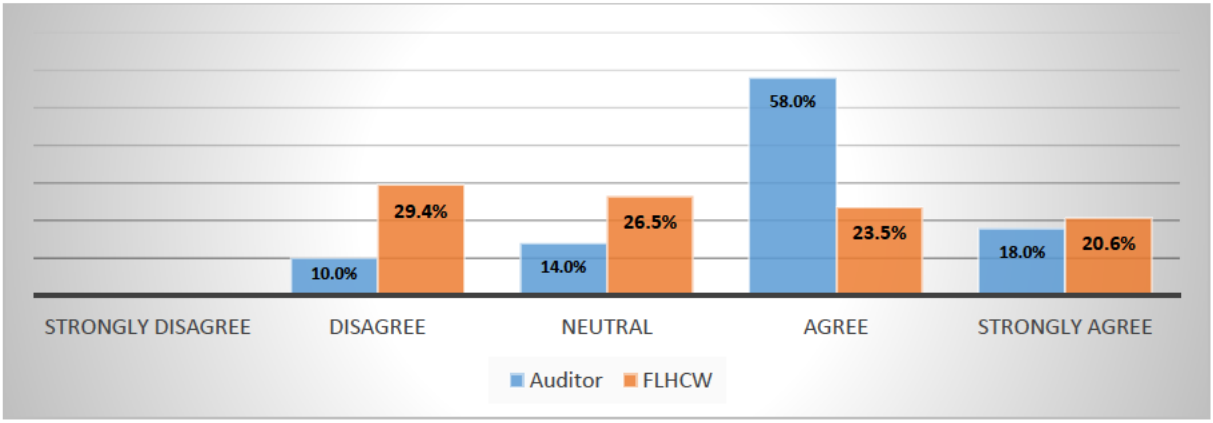


Figure 54. HCW survey respondents' responses to the statement 'My hand hygiene practice remains the same, regardless of the presence of the auditor'.

When interview participants were asked to discuss their beliefs regarding whether direct observation was a satisfactory method of recording normal hand hygiene behaviour, seven out of eight auditors indicated they did not feel that the number recorded realistically represented practice the bulk of the time, that is, when an auditor was not present. Auditors described how they noticed an increase in hand hygiene performance once HCWs realised auditing was taking place:

> *"You know people are changing their habit... because you're standing there with a clipboard... we call it the power of the clipboard basically" [AUDITOR4].*

The majority of auditors reported that, as a consequence, the compliance rate achieved during direct observation was not 'accurate'. In using the term 'accurate', participants were not suggesting that auditors performing direct observation were incorrectly identifying compliance or noncompliance with the WHO 5 Moments, rather that the practice and subsequent compliance rate being recorded did not accurately reflect so-called 'normal' hand hygiene behaviours, which occurred when auditing was not taking place. Whereas the terms 'reliability' and 'validity' would be more appropriate from a methodological consideration, use of the term 'accurate' is reflective of the participants' voices in this context:

> *"I don't think you can get accurate compliance data... (laughs) personally... the staff in the department that I worked in used to laugh at me and they would call me "AUDITOR5 of the handwashing police" and they would kind of like start splashing hand hygiene product around... yes 'here we go... I'm doing... I'm doing it... I'm gonna ... you know... put some under my armpits" (laughs)..." [AUDITOR5].*

Frontline HCWs concurred with the effect of the presence of the auditor and the inherent lack of reliability and validity of the result, one participant labelled the method as not "*truthful*":

> *'Yeah, you like … do a lot more than you normally would…. I don't think it's a truthful method" [FLHCW1].*

Six of the eight interviewed patients also felt that the presence of a human auditor performing direct observation would cause HCWs to perform hand hygiene more frequently and/or more thoroughly:

> *"I'd probably say that, like it's sort of standing there right next to you, of course you're gonna wash your hands, so it doesn't exactly prove that it happens all the time… it just proves that it happens when someone's watching." [PATIENT5].*

Although as one participant noted:

> *"That's fine… it's not necessarily a criticism, it's just, a comment on human behaviour." [PATIENT1].*

Some HCW participants described how auditing was at times conducted covertly and that staff were merely presented with the audit results or were *"tapped on the shoulder and told…"You just got audited"" [GIDr2]*. Several participants who were current or previous hand hygiene auditors related how they felt that the covert approach provided 'better' data as the following excerpt illustrates:

> *"You… actually extract the data quite better to see in realistic terms what they would actually do when you don't tell them to wash their hands" [GINse3].*

One participant was quite adamant, however, that this was not a satisfactory approach, noting that it would be better to make the process more interactive and hence meaningful.

> *"I feel annoyed... because I feel that… it should be much more overt ... it should be much more… "I'm coming in to audit... please just do what you'd normally do and we'll have a chat afterwards about where ... um... I can see that you're not really ... um... doing the 5 Moments correctly…" [GINse1].*

Auditors were generally positive about and accepting of the benefits of using a VMS in terms of enhanced validity and reliability due to less biased data collection which they ascribed as being a consequence of staff forgetting about the presence of cameras:

> *"It would be more accurate… um… as in once the HCW… you know, forgot about having the thing (cameras) on them um… and I think… it does capture the Moments." [AUDITOR4].*

As has been noted many participants used the term 'accurate' to indicate that they saw the potential for a VMS to collect data pertaining to practice unaffected by the Hawthorne Effect or other biases. One participant, however, did describe the benefits of the approach as follows:

> *"I think that it would be a much more valid auditing process… much more about quality improvement" [FLHCW7].*

Group interview participants who took part in the Study 2 trial concurred with the notion that the presence of the cameras would soon be forgotten. Taking part in the simulation scenarios, all experienced the use of video-based monitoring systems during the trial and expressed generally positive responses to the experience noting that the experience felt 'normal' and that they were not really aware of the technology inherent in the process as the following conversation demonstrates:

> *"I forgot… in all seriousness I... at first I... knew… but I forgot..." [GINse2].*

> *" Yes… it was fine... I mean obviously you know it's a SIM (Simulation)... I sort of forget the cameras were there... it just sort of felt like another SIM really... like it was fine…" [GIDr1].*

> *"To be honest at first it was kind of daunting... but the moment that you just keep going in … because your main focus is the patient… you're not focusing on those cameras... when you walk in it... like you know you kind of forget that it's there." [GINse3].*

However, one participant did quantify that a level of awareness would always remain:

> *"(laughs)... you don't forget enough that you do something super dangerous…" [GINse1].*

Overall, the consensus was that footage captured by a video monitoring system would provide a more realistic representation of 'normal' hand hygiene behaviours, as one participant put it succinctly:

> *"…I think that's more... um... like more akin to natural practice because then you start to forget that the cameras are there so yeah." [GIDr1].*

Survey respondents were also asked to respond to the statement 'I think I would soon forget about the cameras' (Figure 55). While most auditors (63.4%) and patients (75%) agreed or strongly agreed that this was the case, only a third of FLHCW respondents (33.3%) responded in this way, suggesting that those who are the subject of recording believed that they would be less likely to forget that data collection was taking place.

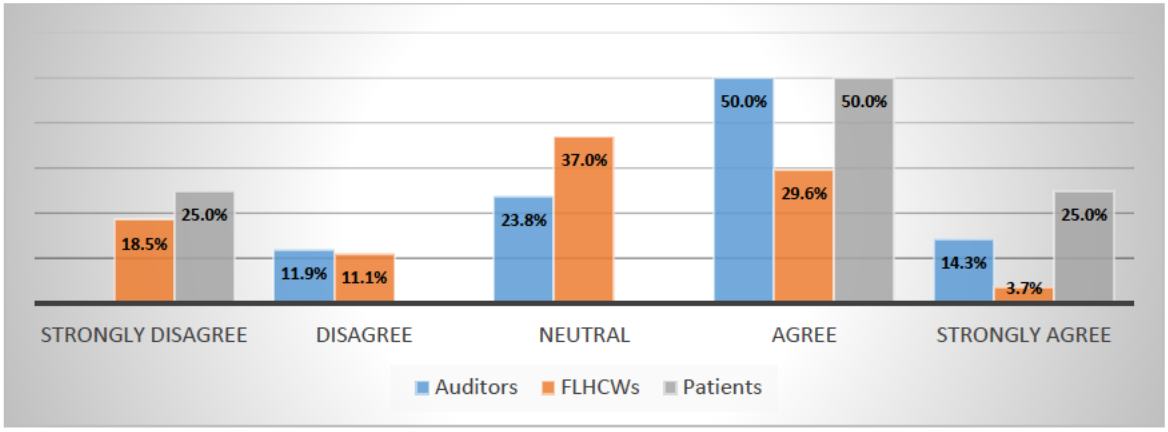


Figure 55. Survey respondents' responses to the statement 'I think that I would soon forget about the cameras'.

Interview participants were clearer in their beliefs that they would soon forget the presence of the cameras with most stating that they thought that this would be the case:

> *"And, you know, whether the cameras would be... people would be mindful all the time, but I suspect that they would forget about them after a while. And they would just get used to them and not even notice that they were there." [AUDITOR6].*

Having forgotten the presence of the cameras interview participants went on to suggest that as a consequence HCWs would behave more naturally and normally as compared to when direct observational hand hygiene auditing was occurring. The result would be the capture of hand hygiene behaviours of a far more genuine nature:

> *"I think you'll get a more honest approach and you'll really see what people are doing ... (laughs) ... or not doing. Yeah" [FLHCW1].*

> *"Yeah, I think it would be more accurate because you're not aware... like... you'll be aware that you're being watched, but not like acutely aware of it... like it'd be sort of more of a... background thing rather than it being like oh suddenly there's a person watching me do this. Yeah so, I think it wouldn't be at the forefront of your mind... so you'd be going about doing your normal job... .doing normal things." [FLHCW2].*

Patient interview participants also commented on the capacity for VMS to capture hand hygiene practice that was more reflective of that which would normally occur:

> *"I mean for me I see it as a step in the right direction because you're... now able to measure what's actually happening. So... I.... I would be comfortable with having that if I was in a hospital." [PATIENT6].*

Several participants did suggest, however, that knowing there were cameras present could have a positive effect on compliance and may encourage HCW to strive for correct practice:

> *"Well even if it changes people's practice, whether the cameras were on or off it would probably… people go "oh look the cameras are watching maybe, you know, I'd better to do it properly". So maybe it would have a… I think maybe a positive effect." [FLHCW4].*

Whether this effect, if it occurred, would be sustained long term would need to investigated.

Interestingly one FLHCW equated the use of VMS with *"reality TV" [FLHCW2]* and the associated filming in healthcare, arguing:

> *"So, like they're doing that for people's entertainment but surely we can do something similar for people's like... education. And… better, you know, nursing practice… like I don't think that's a bad thing." [FLHCW2].*

Other respondents also likened the use and subsequent forgetting about the presence of a VMS to the increasing use of CCTV in broader society. While the majority of respondents indicated that they were not consciously aware of the prevalence of cameras in their daily lives, when prompted to think about the issue they could identify multiple locations where they would be subject to filming:

> *"I mean, it's not something I really think about, but I guess yeah, things like train stations and on public transport and things. But… and I guess in supermarkets and things, sometimes if you see yourself walking in on the, on the screen, but it's not something that I'm too bothered by, or think, too hard about, but I guess yeah they are around." [PATIENT3].*

Some were far more aware of the constancy of surveillance in a variety of locations and through a variety of means as part of their daily life. They had, however, become somewhat desensitised to the notion of being monitored:

> *"I would say… because obviously when you go like shopping centre or train there's footage… CCTV everywhere, you sort of like… don't really care… don't really think about it." [AUDITOR8].*

Having indicated that they anticipated forgetting about the presence of cameras in the clinical setting, and as a consequence that there would be the capture of more valid, reliable and overall all representative hand hygiene practice, participants also suggested that the output data would also be

better as a consequence of the enhanced ability to review and extract compliance results from the VMS data.

Efficacy and efficiency of reviewing the data

While the diminution of the Hawthorne Effect was partly identified as a reason for more 'accurate' data, participants also noted the advantage of the increased efficiency and efficacy of auditing from video footage. Participants stated that the data could be captured with less human intervention and reviewed more quickly. In addition, analysis could be more thorough and certain due to the ability of to audit without interruption and to take advantage of pause and rewind functionality as part of the review process.

The expectation was that auditor respondents would be more likely to see the time saving benefits of the approach, however, this was not demonstrated by the data from the surveys (Figure 56) with slightly more FLHCWs agreeing or strongly agreeing that the approach would be faster as compared to auditors. It is possible that the survey format did not provide respondents with sufficient technical information as to the potential time savings inherent from auditing from recorded footage.

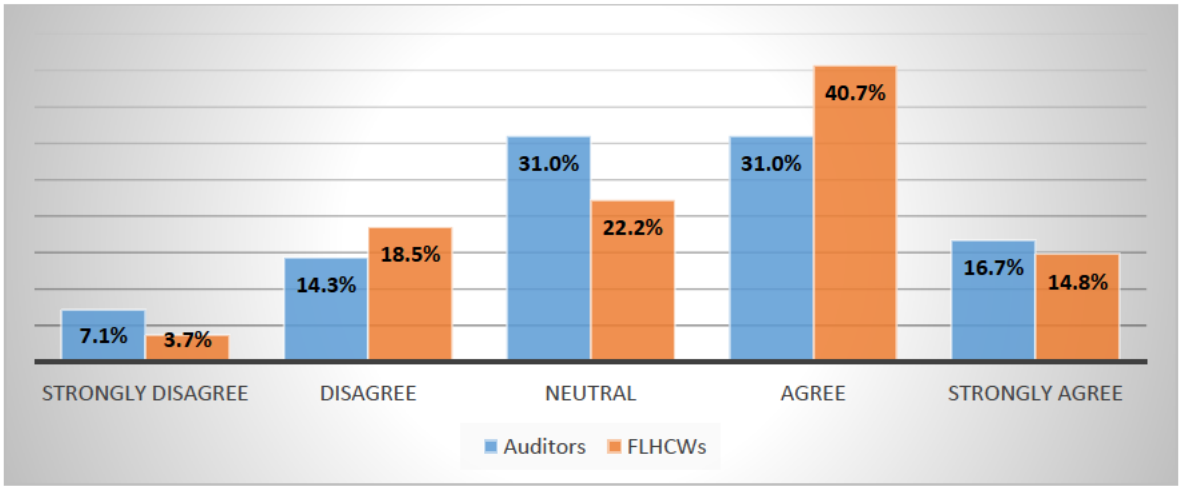


Figure 56. HCW survey respondents' responses to the statement 'Auditing via the VMS footage would be faster and less resource intensive than direct observation'.

Potential efficiencies of data collection and auditing were also raised as an advantage by interview participants, where auditors were foremost in identifying the time savings offered by the approach:

> *"It would certainly speed up the audit process as far as I can see because you then... just flick through and see there... this is the Moment here and get... you're not sitting through hours... or standing through hours of tedious auditing..." [AUDITOR1].*

Several FLHCWs and patients also commented upon the potential for increased efficiency because of this form of data collection:

> *"I think in terms of resources and things, it's much more efficient than having someone follow... follow around another person marking off a clipboard... seems a better use of resources to do it the recorded way, for sure." [PATIENT3].*

Another aspect of the quality of the data gleaned from using a VMS was, the greater ability to be certain of what had occurred, via pausing, rewinding or viewing in slow motion to assess if hand hygiene and/or patient contact had or had not occurred. Questionable or uncertain situations could be double-checked or clarified with colleagues:

> *"I guess it would give you the footage if you needed to... go back… you know, check something for the second time, all that less. I mean, I just I guess there's less room for kind of human error or less subjective than having one person ticking it off? Or if there is any question raised that you've got footage there to actually check, check again. Sort of double check it." [PATIENT3].*

An enhanced ability to concentrate on the task of auditing when it was occurring away from the clinical setting was also raised as an advantage. Participants spoke of the busyness of the clinical setting and how easy it was to become distracted. One HCW indicated how they might question results recorded by a human auditor in a demanding ward environment:

> *"I'd probably feel a bit like… and… in the nicest possible way... because I don't think I'm judging … but you do kind of wonder whether they are really observing you or do they get caught up in chatting?" [FLHCW8].*

Auditors themselves also worried about becoming distracted in the clinical environment, particularly when there were multiple HCWs to watch simultaneously. Participants indicated data would ultimately be more accurate if they were able to take their time reviewing the footage in a quiet and distraction-free setting:

> *"Because you always cannot recap the… sort of like… you know… sort of standing in a corner and like staring at them both … both at the same time… Because obviously, let's say sometimes if I'm staring at patients and staff and sometime I might like… all of a sudden… I might have like a blank moment and I could miss like a few seconds, but obviously with the footage you will like never miss any moment… If you think it's incorrect or if anything happened really." [AUDITOR8].*

Rich and contextual data

Not only did interview participants feel that the data would be more 'accurate' but were also at pains to point out that it was richer. That is, a camera-based approach would capture HCW practice in context. One auditor, for example, described the insights and benefits they had gained from the use of footage recorded in the public hallways of their facility:

> *"Looking for transmission events and with CCTV we found that we were really picking up on a lot of human behaviour factors and we started to learn a lot from that." [AUDITOR2].*

Another auditor clarified this thought suggesting that not only would the footage reveal whether hand hygiene occurred or not, but perhaps more importantly may assist in revealing the 'why' which HCWs are often unable to fully articulate:

> *"…we can learn what are maybe some of the blockers that we weren't aware of to … hand hygiene we just… assume it's always easy and maybe it's not." [AUDITOR3].*

Auditors in particular saw the opportunity to locate hand hygiene compliance within the context of a host of other clinical activities ranging from ANTT, transmission-based precautions, 'clean between' of shared patient equipment, PPE usage, manual handling and ergonomics through to general compliance with clinical practice guidelines or procedures:

> *"So there's other great things… like I can provide you feedback about… your PPE use, I could provide you feedback about your interactions with staff, so I think it would be really rich data… like video footage to be able to collect to have a look at other things." [AUDITOR5].*

Somewhat surprisingly, one patient also picked up on this potential, noting:

> *"And then obviously actually observing what people were doing it would help you measure and find out what's happening with… If they are following that hand washing thing or any other practices not just hand hygiene." [PATIENT6].*

Several healthcare workers reported that that trying to introduce such an approach on the basis of the ability to improve patient care might be difficult for the 'general public' to understand as there was a belief that healthcare facilities were already safe:

> *"I wonder, what the understanding at the public level is about the importance of hand hygiene… you know, the, the infection rates in hospitals do we need to sort of actually explain to people why this is so important, because, I mean, some of them*

> *are just blissfully ignorant and think that hospitals are a lot safer than they actually are… I'm sorry to say that… but maybe… maybe that needs to be part of the consenting process. Not wanting to put fear of God into people, but making it clear why this is so important… Because the flip side is that they might be having their privacy invaded a little bit so they have to see… why this is important… and if people don't see there as being the issue with hand hygiene… they probably would... think the camera thing was a bit intrusive and the top." [FLHCW7].*

For some there was a dilemma as to what was most important, privacy or safety:

> *"It's safe to be monitored. So, if you're thinking about safety, yes, it has to be monitored, but if you're thinking about privacy, then it's the other way around… mmmm… It's a bit hard… Isn't it" [FLHCW5].*

Other participants were clearer, indicating that they saw improved safety and quality of care as more important than the potential invasion of privacy that may result from the use of a camera system:

> *"Yeah... they'd probably rather not get an HAI [hospital acquired infection] and not mind if cameras yeah…"[AUDITOR2].*

The general consensus across the bulk of the interview participant population was that if the clear aim of the process was to improve patient care, then the use of video-based surveillance was valuable and further if there was evidence to demonstrate the benefits of the approach then it certainly should be embraced:

> *"I think everything we do in healthcare is evidence-based practice. So, if there was evidence to prove that that was going to, you know, improve patient outcomes and improve patient safety, and then, like… that it'd probably be improving safety in other areas of work… I think people would be accepting of it… Like… Yeah, definitely." [FLHCW2]*

One patient, who related a particularly harrowing healthcare experience, could also see the benefits of the approach in terms of the 'greater good'. Not only could the use of a video monitoring system have been of benefit to them personally but it could have helped to improve care for others in the longer term, again knowing that they and others would receive better care as a result would make the use of a VMS more acceptable:

> *"I think if it meant that I was helping get better practices and making sure that everybody did the right thing, then I wouldn't mind… In my last hospital situation*

there was something that happened that I would have been happy for it to have been filmed... because I would have had… something… it wouldn't have been a he said, she said scenario… and I know that that nurse wouldn't have done what she did if she's been filmed… there'd be protection for vulnerable people… Yes. Yeah, I think that's… yeah, I think there's good in it." [PATIENT8].

Summary

The aim of Study 3 was to explore the acceptability of the use of a video-based monitoring system for the auditing of hand hygiene compliance amongst HCW and patients. Patients, FLHCWs and auditors were variously surveyed, interviewed individually or participated in group interviews to elicit their feelings and responses regarding the acceptability of the proposed VMS approach.

Broadly speaking, VHS for hand hygiene was acceptable to HCW and patients participating in this study, although this acceptability was conditional on a range of factors and considerations. Patient privacy was a significant consideration to many HCWs but less so to patients. Specific technical features were identified as helping to improve the acceptability of the approach via the enhancement of patient privacy. First and foremost was the use of a proximity beacon, meaning that patients were not recorded if a HCW was not present. Rear camera positioning, facial pixilation and not recording audio also seemed to have a powerful impact on acceptability. Use of an active indicator such as a light or illuminated sign, as well as the ability for patients to control the recording process were also seen as beneficial features. The potential for HCWs to be able to deactivate cameras was less clearly endorsed.

A major consideration for acceptability to HCW were the fears they held with respect to embarrassment, loss of face or concerns regarding punitive or legal consequences as a result of recorded poor practice. The negative emotional responses to the concept of a VMS were in many ways similar to those reported in response to being subject to direct observational auditing and the feedback associated with the process.

Most respondents and participants expressed the importance of open communication and clarity in any implementation process. Buy-in by all involved was seen as important as was the clear articulation of how the system would work terms of recording, reviewing, retaining and deleting the footage. Legal status of the footage will also require clarification, codification and communication as part of the process to enhance the acceptability of the approach.

The lack of a physical presence in the clinical area along with the loss of immediate feedback was initially seen as a disadvantage, reducing the acceptability of the use of VMS for auditing hand

hygiene compliance. However, respondents and participants could also see the advantage of using recorded footage to provide detailed and contextual feedback. Assurances as to the method, nature and quality of feedback were also considered significant factors to increase the acceptability of the approach.

Data and the associated compliance rates recorded using VMS were seen as less biased, and hence more valid and reliable, in terms of their reflection of 'normal' hand hygiene practices than those achieved from data collected by direct observation. The capacity of a VMS to provide richer data that in turn could be used to improve quality and safety of patient care was also noted as a factor which increased the acceptability of the approach.

Chapter 5 now presents a critical discussion of the results of Studies 1, 2 and 3 and the utility of VMS for hand hygiene auditing relative to the literature.

CHAPTER 5: DISCUSSION

INTRODUCTION

The aim of this doctoral study was to explore the utility of VMS for hand hygiene auditing. As is outlined in Chapters 1 and 2, the current gold standard for data collection in hand hygiene auditing is direct observation. While widely used and endorsed, this method is now increasingly questioned and viewed as a time-consuming way to collect small samples which do not necessarily reflect typical practice. However, the variously proposed, trialled and reported electronic measures promoted as a solution to the 'problem' of direct observation are also not without drawbacks, most notably in their inability to collect data according to the WHO 5 Moments framework.

As was presented in Chapter 3, three interconnected studies were employed to examine the utility of VMS and answer the following three questions. First, what technical and methodological specifications might be required for the use of VMS for hand hygiene compliance auditing? Second, what is the accuracy, efficacy and cost-efficiency of the video-based approaches for hand hygiene compliance auditing? Third, what are HCWs' and patients' attitudes to video-based surveillance for hand hygiene?

This doctoral study found that VMS do have utility for auditing hand hygiene compliance according to the 5 Moments, the results of which have been reported in Chapter 4 and will be discussed here with reference to the existing literature.

METHODOLOGICAL AND TECHNICAL SPECIFICATIONS

In 1969, Peltier et al. (1969) reported benefits as to the use of "*television videotapes*" (p. 233) to record and improve practice in the emergency department. While the authors advocated the ongoing use of the modality as an improvement strategy, they highlighted the importance of answering several questions that arose concerning the legal status of the footage, its place as a part of the patient record and the potential for use in both performance appraisal and as a quality improvement tool. Five decades on, similar questions are still being asked and while issues remain unresolved, they inform the features of a prospective VMS.

The recording of HCW – patient interactions is technically possible as the footage obtained via the pre-existing camera array described in Study 2 demonstrates. The reactions to this approach, however, illustrate how the acceptability or lack thereof can be a limiting factor in implementation of an approach despite the technical capacity to achieve the desired outcomes. The proof-of-concept trial provided important learnings, which helped to define what would be needed in terms

of the technical and methodological features of a viable VMS to collect data consistent with the WHO 5 Moments in an effective, efficient and accurate way. In addition, the responses by participants in Study 3 provided insight into technical features and methodological aspects that improved or inhibited the acceptability of the approach, further refining how a VMS should work. It was not, however, the aim of this study to arrive at a single universal truth in terms of the workings of a VMS for hand hygiene compliance. Rather it was to establish, via the proof-of-concept trial, interviews and surveys, the overarching guiding criteria that might be needed in terms of capacity, functionality and principles of operation to balance the goals of efficiently and effectively collecting accurate data that can be audited according to the WHO 5 Moments criteria. In addition, doing so in such a way that is acceptable to consumers and HCWs. To that end, a suite of technical and methodological features and specifications were compiled, which describe a system that is both technically able to capture the required data, as well as be acceptable to both HCWs and patients (Table 29).

Technical Features

Camera Density

In order to allow hand hygiene auditing to take place according to the WHO 5 Moments criteria, visualisation of the entire patient zone (excluding bathrooms/toilets) is required, along with adjacent areas such as corridors, storerooms, medication areas and clean and dirty utility rooms. The reason for this is the fluid and yet contextual nature of hand hygiene practice. For example, hand hygiene does not just occur upon entry to/exit from the patient zone or in the case of Moment 2, exclusively within the patient zone, in order to be deemed compliant. Two examples which may serve to illustrate some of the complexities of recording hand hygiene compliance are as follows. Firstly, deferred hand hygiene Moments, which occur when a HCW has an actual or potential exposure to a body fluid within the patient zone, such as emptying a urinary catheter drainage bag, but rather than perform hand hygiene upon exit from the patient zone ‘defers’ it until after the body fluid has been disposed of, usually in the dirty utility room (ACSQHC, 2019). Provided that nothing is touched enroute and prior to the performance of hand hygiene, this is correct practice, but may be recorded as missed or not recorded at all if sufficient camera coverage is not available. The second example is a so-called double Moment. This can occur when a HCW concludes a clinical interaction within a patient in one zone, performs hand hygiene and then proceeds directly to the next patient zone. No additional hand hygiene is required prior to touching the second patient provided that nothing is touched in the interim; in effect the single hand hygiene episode is counted twice (ACSQHC, 2019). Most, if not all of the electronic monitoring systems, particularly those which use zoned entry/exit as a compliance metric, are unable to distinguish double Moments and will

therefore record a missed hand hygiene Moment in this context. This issue was identified as one of concern by Boscart et al. (2010) who described them as "merged opportunities" (p. 520) and identified them as particularly problematic for entry/exit systems to identify. For video-based systems however, provided sufficient cameras were in place, both a deferred and a double Moment would be correctly identified and compliance accurately audited.

Table 29. Technical and methodological specifications for a video-based monitoring system to record hand hygiene compliance for auditing according to the WHO 5 Moments

Technical	**Methodology**
• Sufficient camera density • HCW proximity activation • Rear/overhead cameras (270^0 or 360^0) • Use of privacy filter/pixilation • No audio recording • 'Recording in progress' indicator • Simple user interface (patients can deactivate) • Ability to easily review footage	• Privacy – appropriate legislative mandate to record within patient zone • Confidential management of footage • Status of footage – legislative clarification required; • Discoverability (FOI, Litigation) • Retention (duration – standard vs sentinel event) • Deletion • Consent – legislative clarification of; whether, how and by whom it is to be obtained • Feedback – outline of process

Proximity activation

Participants advocated a strong preference for proximity activation of cameras, meaning that patients would not be recorded when they were alone in their room with no HCW present and thus when there was no requirement for hand hygiene to be performed. This would not only afford patients a significant degree of privacy, but the use of HCW proximity beacon activation would also significantly reduce the bulk of footage recorded, needing to be reviewed and stored. Proximity activation at trial was facilitated via the use of Bluetooth beacons attached to staff identification tags. Additional options also exist, including the use of RFID technology and the recent facial recognition/machine learning work by Nguyen-Duc (2022) and Chan (2022 - prepublication).

Camera placement

Rear or overhead camera placement was also favoured as compared to side or front on views, again diminishing the intrusiveness of the recording process. Study participants indicated that they found this camera perspective far less personal and that it placed the focus more on the care

activities such as hand hygiene rather than on the individuals. Themes from Study 3, discussions with technical experts and reports in literature, such as that of Diller et al. (2014), support the use of 270° fisheye rear-placed, 360° overhead dome or other similar wide angled cameras as having capacity to provide an appropriate clarity of view, as well optimal privacy in the circumstances.

Facial pixilation

Automatic facial pixilation or similar forms of privacy filter, whist not totally precluding identification of individuals was a feature that provided reassurance and enhanced acceptability and hence was a component worthy of inclusion.

Non-recording of audio

The deactivation of audio recording was viewed in a similar manner as the inclusion of facial pixilation, again providing a measure of reassurance and comfort whilst not impacting the ability to collect appropriate data to allow auditing as per the WHO 5 Moments. The preference for the non-recording of audio identified in this study was in line with the findings of Le Bris et al. (2020) who found that both their HCW and consumer participants, in their NICU-based study involving the use of above-crib cameras, expressed concerns about potential self-censoring behaviours if the recording of audio occurred.

Recording In progress indicator

Another feature that participants believed would enhance the acceptability of the use of a VMS was the inclusion of visual or audible indicators that recording was in progress. This might be in the form of a simple light, an illuminated sign and/or an audible signal.

Ease of use

Ease of use was also considered to have a significant impact on whether study participants believed that within-zone cameras would be acceptable. This was associated with positive feelings towards the idea that patients could be permitted, and by extension, be able to turn the cameras off. Several authors (Conway, 2016; Dyson & Madeo, 2017; Wang et al., 2021) highlight the importance of system “usability” as having a positive effect on acceptability. Hence, the simplicity and utility of the user interface is an important technical aspect of any VMS for hand hygiene auditing. Granqvist, Ahlstrom, Karlsson, Lytsy, and Andersson (2021) concur, stating that “in an increasingly stressful work situation, there [is] no time for additional work and well-functioning technology [is] therefore a prerequisite” (p. 5).

Ease of review

Being able to record suitable footage is only one aspect of the desirable technical specifications of a VMS. The experience of auditing the footage recorded in Study 2 highlighted the importance of quality video management software. Being able to pause, rewind and importantly fast-forward (x16 in one system) meant that the speed, efficiency and accuracy of auditing could be dramatically enhanced. Responsive and purpose created software meant that it was far easier and much quicker to audit from footage, even on the first attempt. In addition, the primary work with the tracking of individual HCWs via the Bluetooth proximity beacons, in order to capture and audit the 'journey' through the clinical space, shows promise in terms of reducing the bulk of footage and making auditing easier and more efficient. Similarly, the work of Diefenbacher et al. (2020) and Chan (2022 - prepublication) appear to have applicability and potential in terms of mapping and subsequently auditing the hand hygiene imbedded within the sequence of care.

Methodological Specifications

In addition to the technical features of a VMS, there are also methodological specifications which need to be clarified for the use of a video-approach to hand hygiene auditing. Another way to look as this is to consider what the 'rules of engagement' are for the use within-zone VMS.

Privacy and Legislation

Having established the technical capacity to record appropriately auditable footage, in a way that is generally considered acceptable by consumers and healthcare workers, there are still questions as to privacy and the associated legislative restrictions and requirements. Issues of privacy, particularly patient privacy, have long been held up as justification for not locating cameras within the patient zone (Boyce, 2017b; Palmore & Henderson, 2012; Ward et al., 2014).

As was found in Study 3 and as will be discussed, patients do not appear to find the concept unacceptable provided certain caveats, embodied in part in the technical features just described, are met. What is in need of clarification at present, relates to the legislative frameworks surrounding privacy and consent. In the Australian context there is significant and at times conflicting status attributed to the recording process inherent in the use of a VMS for hand hygiene compliance, across various jurisdictions. Unfortunately, a review of the Australian Privacy Principles Act (Government 2014) does not clearly illuminate the matter. Whilst stating that consent is required for all video-recording activities, a sub-clause provides an exemption which indicates that the collection of data that is "relevant to or necessary for research, the compilation or analysis of statistics, public health or public safety" may constitute a "permitted health situation" whereby the circumstance is exempt from normal consent requirements (Australian Parliament, 2014, p. section 16B).In some

jurisdictions “workplace surveillance” is permitted, except in areas such as bathrooms, and provided that recorded footage is not “communicated or published” (Parliament of Victoria, 2019). The same Act goes on to further stipulate that neither consent or notification is required for the use of overt body cameras worn by police, ambulance officer or other proscribed persons in the course of their duties. This applies even to the recording of “private activities” and extends to permission for the use of the footage for education, training or “any proscribed purpose” (Parliament of Victoria, 2019). The Act also notes that the footage must be “destroyed” if “satisfied that it is not likely to be required” (Parliament of Victoria, 2019). However, in this case there is no stipulation as to any required duration of retention. In an alternative jurisdiction, the Surveillance Devices Act (Parliament of South Australia, 2016) provides for a “Public Interest” exemption (section 6) which indicates that recording of a private activity is permitted when it is in the public interest to do so. However, in alignment with the Australian Privacy Principle, the information cannot be publicly communicated or published and this could be read to mean that recording for the purposes of hand hygiene is permissible. In contrast, the Workplace Surveillance Policy Directive (Government of South Australia, 2019) produced in collaboration with the Department of Health in the same jurisdiction indicates that “excessively personal information” must not be collected, that filming cannot occur in an area where there is a “reasonable expectation of privacy” and that this could include bedrooms, bathrooms or toilets which would preclude within-zone recording for hand hygiene auditing. However, the situation is further confounded by an exemption within the directive which permitted the use of video recording within the aged care setting “in private areas with the consent of care recipients and/or others legally able to act upon their behalf” (Government of South Australia, 2019, p. section 3.3.18).

Hence the question of whether and in what specific form recording is currently permissible in areas such as patient rooms, even with consent, is clearly complicated and more than somewhat ambiguous at present. Continuous recording via fixed cameras is both clearly permissible and currently occurring in many, if not all, healthcare facilities as a simple online search using terms such as ‘healthcare facility security surveillance’ reveals. Similarly, many HCWs and Hospital Security Officers wear body cameras and may record private activities without either notification or consent. Where then does the status of within-zone recording for the purposes of hand hygiene auditing and ultimately the improvement in the quality and safety of care stand? It is clearly beyond the scope of this doctoral study to resolve this question. What is clear however, is that explicit legislative mandate outlining the circumstances where and when the recording of footage within the patient zone is permitted, will be required as a part of the methodological specifications of any use of VMS for hand hygiene compliance auditing.

Confidentiality of Footage

Confidentiality is another area which will need to be considered. Participants stressed the necessity of the footage being treated in a confidential manner as per the Australian Privacy Principles (Australian Parliament, 2014) and the various surveillance devices acts (Commonwealth, 2016; Government of South Australia, 2019; Parliament of South Australia, 2016). While exemptions permitting recording do exist, there remains the restriction on publication or communication of the footage. Study participants concurred, stressing the importance of restricting who had access to the footage to those who had a need to see it and who understood the importance of treating it in an appropriately confidential manner. It will therefore be important that the confidential management of any footage recorded using a VMS be within a clearly communicated legislative framework and be an important part of the methodology for the use of the approach.

Retention, Security and Deletion

Another methodological aspect of video-based surveillance for hand hygiene and other similar practice auditing, relates to the management of the secure storage and appropriate destruction of recorded footage. Various legislation and standards (Australian Parliament, 2014; Commonwealth, 1988, 2016; Government of South Australia, 2019) dictate that there is the expectation that all reasonable care is taken to securely store any recorded footage and that, as was noted, information must not be publicly communicated or published without consent or appropriate authority. Australian Standard AS4806.1-2006 (Closed Circuit Television (CCTV))(Australian Standard, 2006) recommends the retention of all footage for a period of 31 days, after which time it should be destroyed if it has been deemed unrequired. However, participants in the study who reported experience with the use of CCTV in healthcare, related how the footage recorded in their settings was retained for only 7 – 14 days before being deleted, suggesting the need for the tightening of practice around the handling of recorded images. There is also the question of whether an image recorded in the patient zone is considered a part of the patient record and if this in turn effects the rules and requirements associated with retention and/or deletion. A review of the Victorian Health Records Act (Government, 2020 Update) as an example, indicates that the unlawful destruction of health records is an act subject to penalty (up to 300 units); however it is not clear whether footage recorded within the patient zone would be constituted a “patient record”, particularly if the privacy and de-identification measures as have been described were applied. Whereas, according to the Office of the Australian Information Commissioner (Commonwealth of Australia, 2022), medical records in most jurisdictions must be retained until the patient is 25 years of age or for seven years (whichever is longer). Thus, if footage is deemed to be a part of the patient record under this guidance it would need to be kept for that duration. As noted however, the status of VMS output

data is currently unclear (Gelbart, Barfield, & Watkins, 2009). Conversely, patients may be recorded outside of the patient zone, for example in hospital corridors, waiting areas and other shared spaces and it is clear that this footage is not retained as part of the patient record at this time. Indeed anecdotal reporting from study participants would suggest that it is not even kept for the 31 days recommended in AS4806.1-2006 (Australian Standard, 2006). Hence it could be argued that an image of a patient in a healthcare facility does not automatically become a part of a patient record. What is also clear is that clarification of the status of data collected using VMS will be needed as part of any codification of the operational methodology for VMS for hand hygiene auditing. It is also important to consider, as van Dalen et al. (2019) note, while video surveillance is both common and accepted in many industries such as aviation, offshore oil rigs and maritime transport, it operates in these contexts within an embedded legal and operational framework which is, at this point in time, lacking in healthcare, again highlighting the need for specific legislative mandate relating to the approach.

Participants in this work did express concerns relating to the implications of longer-term footage retention but could also see the need for such a practice in certain circumstances. There was a general consensus that footage would need to be kept if any criminal activity was detected (e.g. assault, theft), when any behaviours which fell under mandatory reporting requirements were noted (e.g. child or elder abuse) and/or when episodes of malpractice were observed. In these instances, open disclosure was supported, as was the provision of copies of the footage to the relevant parties and authorities. The temporary retention of footage for education or quality improvement purposes was also deemed acceptable and is in line with the exemptions in the Privacy Principles (Australian Parliament, 2014) where footage from body cameras can be used for educational purposes. Study participants also indicated that they believed that if recorded footage did not contain any material that met the above criteria for retention, then it should be deleted within a short period of time, with seven days being the usual suggestion. Whether this is or would be permissible in the context of the status of the footage is unclear; however, the explicit illumination of the process of retention and deletion clearly needs to form part of the methodological specification of the approach.

While concerns about external unauthorised viewing and distribution of footage did not feature to a greater extent with participants in this study, the potential for ‘hacking’ of the data was raised. Having a process to ensure safety and security of the footage would clearly be important in terms of both the technical/methodological specifications of the approach as well as a means to promote and encourage acceptability of the process. N. A. Brown et al. (2017) advocated the use of password protected storage with encryption to ensure the security of the recorded footage. They

also recommend that the information and consent process for the approach includes details of who will have access to the footage, all of whom should be required to sign a confidentiality agreement.

Consent

The issue of consent is another aspect that would need to be clarified and would form a part of the methodology for the use of VMS for hand hygiene auditing. The question of whether consent would be required and how it would be obtained would need to be informed by any legislative framework surrounding the permitting of within patient zone surveillance. The current situation is unclear and appears dependent on the jurisdiction within which it occurs as well as potentially how hand hygiene is defined in relation to the legislation. For example, whether the use of VMS to record compliance is deemed essential for public health or is considered a permitted health situation could easily change the 'rules' surrounding the approach (Australian Parliament, 2014; Commonwealth, 1988). Depending on the legislative status attributed to hand hygiene auditing and VMS it possible that consent may not be required, although notification may. However, viewing the situation through the lens of alternative legislation and jurisdiction (Government of South Australia, 2019; Parliament of South Australia, 2016) within-zone recording would only be allowed in an aged care setting and then only with the informed consent of consumers or their agents. The literature is similarly unclear. For example, Jacobs et al. (2010) found routine procedural consent was sufficient to cover video recording as it was deemed a standard procedure within their facility. Hu et al. (2012) on the other hand described an 'opt out' rather than consent driven approach. Weinger, Gonzales, Slagle, and Syeed (2004b) operated under a "waiver of consent" due to the approach being considered a "quality improvement" activity, while in a similar vein, Oakley et al. (2006) were not required to have consent to record paediatric resuscitations as the process was designated an "auditing tool". Similarly, O'Donnell et al. (2008) attest that while consent is required for the use of video recording as a part of a research study, it is not required in the context of an audit or quality improvement activity. The authors go on to cite the NHMRC guidance in support of their stance. The update to the guidelines in 2014 (NHMRC, 2014) states that when the "primary purpose of an activity is to monitor and improve the quality of service" (p. 2) it can be deemed a quality assurance activity. It is argued that hand hygiene auditing via a VMS would fit this criteria. In contrast, Diller et al. (2014) obtained formal written consent from 26 participants to perform within-zone recording. It is worth noting that Parry, Pino, Faull, and Feathers (2016) assert that consumers are less likely to find retrospective consent acceptable, hence highlighting the importance of, if not informed consent, at the very least education of consumers to ensure the awareness of the process before being subjected to it. Le Bris et al. (2020) found that participants in their study involving within-zone

video monitoring, indicated not only was consent for recording important, but also a guarantee relating to the use, retention, access and deletion of the resultant footage was vital.

Participants in this study also commented that consent may be an evolving issue; that is while the idea of video-based monitoring was new, an education and awareness raising campaign for consumers combined with one-to-one written or verbal consent may be required. However, they went on to suggest that as the situation normalised, signage and an "opt out" position where the onus was on consumers to make known their choice to decline would become the norm. What is clear is that clarification of the consent requirements would be essential, and the how and by whom would need to be explicitly outlined as a part of the methodological specifications for the use of a VMS for hand hygiene auditing.

Legality and legal issues

Historically, some of the major concerns and questions regarding the use of video recording HCW practice in the 1969 study (Peltier et al., 1969) centred around the potential for litigation. While the use of video-based surveillance in healthcare has increased in the form of CCTV, video telemetry, falls or behavioural monitoring, and various procedural recording ranging from resuscitations, medical imaging through to intra-operative filming, the legal status of the resultant footage remains unclear.

Another related methodological aspect requiring clarification is the issue of what is referred to in the law as discoverability (Butler, 2018). This could relate to whether the footage is discoverable in terms of a Freedom of Information (FOI) access request by patients or the ability to be subpoenaed as part of litigation. Gelbart et al. (2009) noted that video recordings in the Australian healthcare context were generally exempt from the FOI process but then admitted that there "were a few exemptions" (p. 122). As a rule, evidence from the literature would suggest that the status of a recording as audit data, as a quality improvement activity or as part of the patient record will impact on whether there are additional local statutory requirements as to the integrity of data protection, storage and retention (Iserson, Allan, Geiderman, & Goett, 2019; van Dalen et al., 2019). In the United States, the literature would suggest that there would be provision for such footage to have protection against discoverability on the basis of being constituted as a quality improvement activity (Weinger et al., 2004a). van Dalen et al. (2019) note that footage collected for quality improvement purposes do not form a part of the patient record, but then go on to add that where this line is drawn remains unclear in many settings. As was noted above, what the status of such footage is in the Australian context is unclear. There is also the question as to the impact of deletion of footage following auditing or after a specified short interval upon the discoverability and

any risk inherent in the deletion of recordings. A survey of institutions in the USA which use various forms of video-based auditing would suggest routine deletion is in fact a common practice (den Boer et al., 2018). However, again, the question of whether this would be permitted in the Australian context is another area requiring clarification.

Despite the fears regarding medico-legal risk, evidence would suggest that litigation is an uncommon occurrence and these fears are in fact contrary to reported evidence which would indicate that the use of video is more likely to exonerate than condemn a HCW faced with an allegation of serious misconduct (Berridge, Halpern, & Levy, 2019; O'Donnell et al., 2008; Renkema, Broekhuis, & Ahaus, 2014; van Dalen et al., 2019). Furthermore, open disclosure has been a mandatory practice in Australia since 2003 (Care, 2012; Harrison, Walton, Smith-Merry, Manias, & Iedema, 2019) meaning that any detected adverse events must, according to the National Standards and one would hope, according to the HCWs moral compass, be disclosed to the patient or their next of kin. Wu et al. (2017) suggest that the requirement to undertake open disclosure is a major barrier to the use of video-based monitoring, in that once certainty exists in the form of a clear visual record, there is no excuse of ambiguity not to undertake open disclosure. Renkema et al. (2014) notes that fear of litigation or damaged reputation is a major reason that open disclosure does not occur, and thus by extension this is another part of the reason for HCWs to fear the use of a VMS. Yet, there is evidence that if formal open disclosure takes place, patients are less likely to be upset, angry and importantly litigious, and are conversely more likely to be confident and satisfied with their care even in the context of an adverse event (McLennan, Rich, & Truog, 2015; Walton et al., 2019).

It is clear that the status of any recorded footage will need to be investigated and addressed as part of the methodological speciation of a video-based approach to hand hygiene compliance auditing. Le Bris et al. (2020) suggest that it may be pertinent to “introduce a specific legislative framework” (p. 7) in order to introduce the use of video-based monitoring within the patient zone.

Feedback

Details of how and when feedback on hand hygiene practice and compliance would be provided is another important aspect of the methodological specifications of the use of VMS for hand hygiene auditing. The loss of immediate feedback is reported as a concern for the use of video-based auditing. However, several points must be made. Such concerns are in variance to the literature which questions the efficacy of immediate feedback as well as the frequency with which it is actually given (Azim et al., 2016; Boscart et al., 2012; Mackrill et al., 2017; McDonald et al., 2018). In addition, the use of video provides the potential for detailed contextual reflection on practice at

an appropriate time and place through review of the recorded footage. Study 2 and 3 participants initially raised, but ultimately rejected, the loss of immediate feedback as a disadvantage of the use of a VMS for hand hygiene compliance monitoring. This response echoes earlier findings in Phase 1 where some participants disdained the utility of video monitoring on the basis of a presumed negative impact of the loss of immediate feedback whilst others disagreed that this was a concern. The results of this study are consistent with existing research (Boscart, Fernie et al. 2012, Azim and McLaws 2014, Azim, Juergens et al. 2016), which holds that immediate feedback in the midst of a busy clinical day is not only rare but also often unwelcome, poorly received and of little benefit In terms of behaviour change and overall practice improvement. Studies also show that the results of hand hygiene audits do not always reach frontline staff, are rarely received as individualised feedback, and often fail to motivate improvement efforts (Livorsi, Goedken et al. 2018).

However, it remains that without performance feedback staff will likely find it difficult to optimize hand hygiene or any other practice. If feedback is not provided, staff may not be aware of their deficiencies. If feedback is provided, but is inadequate and fails to detail where practice does not meet the standard, staff may believe that their practice is satisfactory, and if feedback is unskilled, it may engender negative emotions which overwhelm and obscure the core information which the feedback is intended to impart. High quality feedback is a "requisite for the development of expertise" (Kogan, Conforti, Bernabeo, Iobst, & Holmboe, 2011, p. 1049). And yet, when feedback is provided it will all too often have a "positivity bias" (Albanese, 2000, p. 305) resulting in only good practice being raised with the HCW due to a natural reluctance to give feedback that may be perceived as negative or demoralising (Albanese, 2000; Kogan et al., 2011). In addition poor quality feedback may also have limited discrimination and may not clearly address noncompliance (Albanese, 2000). Unfortunately this can leave the HCW unaware of their need to improve, as Albanese (2000) somewhat caustically notes: "the incompetent do not seem to know that they are incompetent" (p. 307).

Xu et al. (2021) demonstrated the importance of collecting data in order to allow individualised feedback. This practice, along with the consequent ability to specifically target improvement interventions was an important aspect of increasing hand hygiene compliance in their study. The potential for useful and powerful feedback using the real-time footage from video-monitoring was also identified by participants in this study, who suggested viewing it at a later date to unpack hand hygiene practices and learn from either one-to-one feedback or via collaborative discussions. This latter method of learning could be used to augment the more commonly used statistical audit feedback and could take place during planned education forums, for example, at in-service or at the end of multidisciplinary meetings. The learning afforded by video-feedback of

everyday practices in group reflexive sessions has been shown in several studies to improve HCW and patients' understanding and practice of infection prevention and control (e.g. Iedema, Hor et al., 2015; Wyer, Jackson et al., 2015; Hor, Hooker et al., 2016; Gilbert, Hor et al., 2020; Wyer, Hor et al., 2021). Hunukumbure, Smith et al. (2017) contend that not only does video provide an authentic picture of practice, but that it also as a "powerful impact on subsequent improvement" (p. 2). Study participants related how at times they were so caught up with their clinical work that they would practise habitually or automatically without being consciously aware of their actions. This aligns with findings in the literature that clinicians are often unaware of their practice gaps. It is argued that by reviewing recorded footage, HCWs are able to recognise and reflect upon their actions and behaviours in a critical, yet ultimately positive way (Nilsen & Baerheim, 2005; Hunukumbure, Smith et al., 2017; Iedema, Carroll et al., 2019).

What is important in terms of methodological specifications is that while feedback is recognised as essential, there are also negative emotions associated with both the giving and receiving of commentary on practice. It is therefore important that the form, nature and process for feedback utilising a VMS, be clearly spelled out as part of the operational methodology. The how, when, where and by whom for feedback needs to be incontrovertibly outlined so that those subject to the approach are clear as to what to expect. For example, study participants indicated that viewing one's own practice needed to be optional not mandatory, although the majority stated that this was something that they would want to undertake. Hence, the provision of group, team or ward level feedback versus individual would need to be clearly communicated and possibly even codified. While group level anonymous feedback may often be preferred and seen as protective for individuals it may also be less effective. As Granqvist et al. (2021) found with their trial of a zone-based EMS, "the group feedback was perceived as good and useful but the individual feedback was considered even better" (p. 4) and was in fact ultimately preferred by participants. It is contended that individual feedback, contextualised via the use of footage would be even better again.

Participants in this study also stipulated that it was important that confidentiality and privacy be maintained in the feedback process and for the subject of the audit to have control over who, beyond the auditor, would view and provide feedback upon the VMS footage. Again, how these matters would align with any legislative mandate is uncertain. What is again clear, however, is that the process feedback provision needs to be made explicit as part of the methodological specifications of the approach.

Having addressed the features and operational methodology anticipated for a VMS for hand hygiene auditing, the next question to address was the relative accuracy, efficacy and efficiency of the approach.

ACCURACY, EFFICACY AND EFFICIENCY

The second question in this doctoral study was: 'What is the accuracy, efficacy and cost-efficiency of a video-based approach to hand hygiene auditing?' For study participants there were two aspects to accuracy and how it was perceived in the context of a VMS. They frequently used phrasing describing the data collected by a VMS as "more accurate" than that collected via direct observation. They did not mean by this that one method was better, or more accurate per se at deriving a hand hygiene compliance rate from observed practice. Rather they meant that practice recorded with a VMS would more accurately represent normal behaviour due to the absence of the various biases associated with direct observation. They also, by extension, implied that VMS was a valid and reliable data collection method, in that the approach would consistently measure what it was "supposed to measure" (Holloway & Wheeler, 2010, p. 299). The second aspect of accuracy reported by study participants related to a perceived enhanced ability to be certain of what was being observed due to the ability to manipulate the footage (pause, rewind, fast forward etc.), the ability to confer with colleagues about ambiguous situations and to conduct the audit in a quiet and distraction free environment.

The results of this study demonstrate, not only the utility of using VMS to capture and assess hand hygiene compliance according to the 5 Moments framework, but also the capacity to do so with greater efficiency and efficacy. The review of the recorded footage established the ability to clearly distinguish all five of the WHO 5 Moments as they occurred and according to the WHO 5 Moments criteria rather than by proxy measures as have been reported in the literature (Al Salman et al., 2015; Diller et al., 2013). This ability was enhanced via the process of camera-to-camera tracking of the HCWs' clinical journey both within and without the patient zone.

Analysis of the Study 2 trial data also demonstrated that time, and consequently financial, savings were advantages of the approach. Auditing from the footage recorded for both days represented a saving of 86 minutes, when compared to time taken if direct observational auditing had been employed. With a total yield of 111 Moments captured over the six simulation scenarios, it is calculated that auditing from VMS footage saved 84 seconds per Moment if compared to the time which would have been taken if direct observational auditing was employed. It is worth noting that these results were achieved at the first attempt of auditing from footage and that at each subsequent scenario, speed of and dexterity with the review process increased and auditing became

easier and more efficient. This would suggest that even greater savings may be achievable with practice and experience with the approach.

In comparing auditing from footage with that of direct observation, the assumption was made in this instance that a human auditor would be able to capture all of the Moments with the same certainty as was able to be achieved from the footage. It is contended that it is more likely that a higher yield of Moments, compared to direct observation, would be able to be achieved when performing auditing from the footage due to the capacity to freeze, slow and rewind the footage. Also, due to the lack of distraction during auditing, it was able to take place in a quiet environment away from the clinical setting, hence ensuring that all actual and potential hand hygiene was identified and recorded. The results of the study are consistent with the work of Gottumukkala, Street, Fitzpatrick, Tatineny, and Duncan (2012) involving recording of paediatric interventional radiology procedures, in that they contend that there is substantial benefits in being able to pause, rewind and otherwise review footage in terms of enhanced accuracy when establishing compliance. In comparing the footage from the installed fixed cameras (WPZ-FC) system on Day 2 of the trial, with that recorded at the same time via the observation window (NPZ-NFC), it was interesting to note a significantly higher yield of Moments (69 versus 47) was obtained from the multi-camera array which also had the capacity to pause and rewind as needed. The NPZ-NFC output represented a proxy of data collection by a human observer at the observation window of the NBC, as was described in Chapter 3, and hence the footage was viewed in a single continuous episode without the benefits of pause or rewind functionality. The higher yield from the WPZ-FC result is consistent with reports of various electronic monitoring systems which are typically able to accumulate much higher yields of Moments as compared to the same duration of direct observational auditing. D.J. Gould, Lindstrom, Purssell, and Wigglesworth (2020), for example, reports collecting “five times more data than manual observation over the same period” (p. 7) with their system.

It was calculated that auditing using WPZ-FC recorded footage would have an overall cost of AU$99.17 (AU$0.89 per Moment) for the six simulation scenarios in terms of auditor wages (based upon AU$50 per hour), whereas direct observational auditing would have cost AU$171.67 (AU$1.55 per Moment) based on the presumption of the same yield of 111 Moments for the total scenario duration. As noted above, it is unclear if a human auditor undertaking direct observation would have been able to capture all of the Moments that were recorded by the WPZ-FC system. The possibility of a lower yield of Moments for the same time period, for example, gives a time and cost per Moment for the NPZ-NFC data recorded on Day 2 of 2.25 minutes and AU$1.87 per Moment. Even so, these figures are lower than the cost per Moment of AU$2.20 suggested by Azim and McLaws

(2014). With data from the NHHI in Australia showing the collection of almost two million Moments per annum (NHHI, 2022) the potential financial benefits could be considerable via the use of a VMS.

The finding of time saving when auditing HCW practice from footage has been noted in the literature with Hu et al. (2012) estimating a 50 – 80% saving in data review time due to the ability to fast forward the recordings when appropriate. Dath et al. (2004) concur, having found an approximately 80% time saving when undertaking video review of laparoscopic procedures. Beckmann et al. (1995) only reported a 34% time saving in their study, although the authors did acknowledge that the efficiency and time savings increased with experience, which is also consistent with the findings reported in Chapter 4. Further, it is worth recalling that the study by Beckmann, Lipscomb et al. (1995) occurred over 25 years ago and that video review technology has significantly improved during this time. Indeed, in the results reported in Chapter 4, it was noted that there were significant differences in the video review software which impacted upon the ease and speed of the auditing process. Overall, it is argued, that there is support for the contention of enhanced efficiency related to video monitoring technologies, and our results fell within the 34 – 80% range at first attempt and would likely improve with ongoing experience with the method.

While the data collection for the study was only brief, being a trial in simulation the use of a VMS has the potential to collect large amounts of data with very little human intervention. Potentially operating 24 hours a day, across the full 7 days of the week is something that is not logistically possible with direct observational auditing, which rarely happens overnight and during weekends (Fries et al., 2012; Haas & Larson, 2007; Sax et al., 2009a). This extended data capture would further enhance the validity of the overall hand hygiene compliance data and is a noted benefit of many electronic auditing approaches (Boyce, 2017b; Fisher et al., 2013; McLaws & Kwok, 2018).

Another advantage of the approach, as was evidenced in our study, was that recorded footage may also be reviewed at a more convenient time as compared to direct observation, which typically occurred during the day shift on weekdays. The rationale for selecting this time is that the clinical areas are at their busiest and more hand hygiene is being performed, and hence when data gathering is most efficient. However, as has been discussed this practice can not only foster selection bias but can potentially create conflict for local, ward-based auditors who may have dual clinical and auditing roles (Boyce, 2017a; Daniels, 2012; Haas & Larson, 2007). Williams, Klamen, and McGaghie (2003) warns that distractions and competing responsibilities may impair the ability of auditors to perform accurate observations and result in compromised data, further supporting the benefits of performing a review in a quiet environment away from the clinical setting. This was the case in Study

2, where auditing was able to take place in a quiet environment, removed from the clinical milieu. Dagnaes-Hansen et al. (2018) in particular highlight the advantages of conducting video review away from the noise and distraction of the clinical setting in order to allow the auditor to focus more closely on the task. Participants across all phases of the study also identified this as a benefit of the use of VMS.

A useful aspect of collecting data using a VMS is the potential to gather less bias impacted results. With the proposed VMS approach, not only is the practice of all HCWs who come within the view of the camera lens captured, but it also eliminates or at the very least significantly reduces selection bias. There is also the possibility for reduction of observer bias when conducting auditing from recorded footage as compared to direct observation. This was demonstrated in the study by Dagnaes-Hansen et al. (2018) and it is also consistent with the broader literature (Kogan et al., 2011; Yeates et al., 2013). This approach also raises the possibility of departments exchanging footage, particularly where a relationship between auditor and audited HCW exists. This could be equated with the blinding process used in manuscript review and as Albanese (2000) argues, such a practice will make the assessment of competence as "objective as possible" (p. 310) on the basis that having a connection between auditor and those subject to audit "touches an emotional chord that influences a rater's judgement" (p. 320). Inter-auditor reliability issues can be improved when auditing from footage as there is the potential for multiple auditors to review the same episode and to compare results thus promoting consistency and further enhancing the accuracy and validity of the results (Gottumukkala et al., 2012; Woolrych et al., 2015). During the analysis of and auditing of Study 2 data, the footage was able to be manipulated to ensure certainty (rewinding, slow motion and freeze frame) and discussion, review and clarification of difficult or ambiguous situations was able to occur. As a result, data may represent a truer reflection of practice than that produced by direct observation on the basis that one cannot freeze frame or rewind 'real life'. It is also contended that the results are able to be collected without intrusion, have enhanced credibility due to inherent accuracy and completeness of the record. The approach also allows for what Broyles, Tate, and Happ (2008) describe as nuanced levels of analysis, meaning that hand hygiene practice can be viewed, reviewed and improved upon within the overall context of clinical care.

It is suggested that there is also a reduction of observation bias or the Hawthorne Effect via the use of video-based monitoring systems to capture and audit hand hygiene behaviour. This claim is based on the argument that a camera creates less behavioural change than a human observer. This tallies with the results of several studies involving video recording of participants in clinical or simulated clinical contexts where the reduction or elimination of the Hawthorne Effect is reported and where participants reported that they quickly lost awareness of the presence of cameras (Clack

et al., 2017; Hu et al., 2012). Statements supporting this contention were made by participants across all phases in the study, in particular those who took part in the Study 2 trial in simulation and who reported that they quickly lost awareness of the recording process. The upshot of this bias reduction is, it is contended, the collection of far more natural and authentic clinical behaviour and as study participants phrased it “more accurate” hand hygiene compliance information, which in turn would allow for the true identification of practice deficits and open the possibilities for targeted change strategies to improve patient safety and quality of care.

To return to the original question as to whether it is possible to audit hand hygiene compliance using a VMS with accuracy, efficacy and cost-efficiency, the answer is clearly yes. Not only is the data collection more efficient, valid and reliable owing to the reduction in various biases and there is minimal human intervention needed to capture the footage, there is also the ability to be more certain in the analysis of the data through the functionality of features such as pause, slow motion and rewind when needed. Conversely, there is also the capacity to review and audit from the footage with greater speed and hence lower cost. And finally, a greater yield of Moments as compared to direct observational auditing is both possible and likely.

ACCEPTABILITY OF VMS TO HEALTHCARE WORKERS AND PATIENTS

As was identified in the Chapter 2 literature review, negative reactions from staff and potentially patients towards the use of VMS for hand hygiene compliance may occur and hence, a lack of acceptance may prove a barrier to the effective use of these technologies. This may be the case despite the technical ability to achieve a positive outcome in terms of data collection and analysis. To that end it was important to explore acceptability; that is ‘What are healthcare workers and patients’ attitudes to video-based surveillance for hand hygiene auditing?’

In general, participants in the study found the use of VMS for hand hygiene auditing compliance acceptable. The acceptability of the approach came with caveats, however, in the form of technical features, methodological specifications or operational parameters which, when applied, could enhance or diminish the regard in which VMS for hand hygiene compliance auditing was held.

This is where the question of technical and methodological specification and that of attitude and acceptability intertwine. The technical features and methodological parameters described in earlier sections of this work, and summarised and discussed above, were informed both by what was needed in order to collect data, able to be audited according to the 5 Moments criteria, as well as what was deemed necessary by the informants in this doctoral study in order for them to find the approach acceptable. The understanding and meaning that the study participants gave to the

concept of acceptability was explored in Study 3 with the five highly interconnected themes described in Chapter 4 emerging from the data.

The first of these was *protecting patient privacy* and a discussion of this theme serves to illustrate the point with regard to the intersection of technical and methodological features and acceptability to HCWs and patients. Throughout each of the studies which comprise this work, the invasion of patient privacy that a video-based system was held to present, has been offered by HCWs as a major barrier to acceptability and the practical implementation of the approach. In the literature, patient privacy concerns have long been a major justification for not locating cameras in the patient zone. As was noted in the introductory chapters, these issues have been described as creating "inherent tensions" (Palmore & Henderson, 2012, p. 9), "special challenges" (Boyce et al., 2017, p. 532) and of being "fraught with problems"(D. J. Gould et al., 2011, p. 291). However, a number of studies have reported or demonstrated that patient objections to recording are in fact quite rare, once information as to intent and purpose is provided (Clack et al., 2017; Diefenbacher et al., 2020). O'Donnell et al. (2008), for example, found that no parents of patients involved in their study expressed any concerns about the video recording of neonatal resuscitations and that only 2 out of 165 declined to provide prospective consent for recordings. Despite the HCW participants throughout this study rating patient privacy as a major barrier, our interviews with patients did not lend strong support to this notion. Most had a generally positive response to the concept indicating that they found the approach broadly acceptable, provided certain technical and operational criteria were met. Most study participants felt that if the technical aspects of the approach such as proximity activation, camera positioning, pixilation and lack of audio recording at a minimum, combined with full disclosure as to the functioning of the system and consent and/or the ability to opt out easily and without bias, were implemented then the use of a VMS would not represent an invasion of patient privacy. This evolution of opinion demonstrates the importance of the impact that certain technical and methodological specifications which function to protect patient privacy have upon the acceptability of within-zone VMS, as well as of that of the open communication and understanding which was described in Theme 3. Once participants could visualise and understand how the features of the system operated, they were more likely to respond positively to it. These findings are broadly similar to those of Kelly, Blackhurst, McAtee, and Steed (2016). Although their system did not involve the use of video and relied on proxy measures rather than the WHO 5 Moments, it did involve tracking and identification of staff, both of which could have derailed the process in terms of acceptability. However, the authors noted that the inclusion of various features and protections as well as the fact that the system was "introduced sensitively with ongoing communication" (p.5) meant that it was not merely "tolerated" but was deemed "acceptable" by participants.

While the implementation of the various identified technical and methodological specifications previously outlined made a significant difference in terms of acceptability for study participants, they were clearly not the total solution to consumer and to a greater extent HCW concerns. Theme 2 identified the need to make HCWs feel safe while Theme 5, named *better data, better feedback, better care* and identified the importance of quality data as an essential aspect of providing better and safer care.

A significant dichotomy existed for study participants, a head versus heart dilemma. While they could identify the clear benefits, on multiple levels, of the approach, there was also a distinctly negative emotional response. The explanation of the construct of acceptability by Parry et al. (2016) encapsulates the issue:

> *"Acceptability is a judgement based on the reasonable anticipation that involvement in a study will not cause harm to the participants, that their autonomy will be respected, and that the possible burdens associated with taking part will be outweighed by the anticipated worth" (p. 1272).*

As was noted in Chapter 4, the study participants engaged in the discussion of whether the risks associated with the use of video-based monitoring such as the perceived invasion of privacy and HCW's discomfort relating to surveillance, outweighed the benefits of efficient and accurate data collection and the subsequent potential to enhance the quality of safety of patient care. While most participants came out on the side of safety trumping the other risks it was also a position which was tempered by a variety of personal beliefs and experiences. However, it was also one which was nonetheless amenable to the influence of evidence as to those benefits. This is a common trade off, for example, Le Bris et al. (2020) found that consumers and healthcare workers in their study valued the use of video if it improved care. Similarly Scott et al. (2020) found that participants in their study valued recordings on the basis that "they may support their potential to improve services" (p. 25). This would suggest that in general, once those involved understand the benefits of the use of a VMS, they may view its use in a more positive light.

It would appear that underlying the intellectual or academic knowledge of the benefits of the approach, there is also a degree of apprehension if not fear. Mostly expressed or identified by HCWs, but also to a lesser degree by consumers, these fears and the technical and methodological features needed in order to ameliorate theme are a significant factor in *making HCWs feel safe* and hence improving the acceptability of the use of VMS for hand hygiene compliance. For HCWs, the reassurance provided by the clarification of the legislative framework relating to privacy, consent, discoverability and the legal status of footage would be significant. However, over and above this

there is still fear, or at the very least reports of anxiety, associated with being the subject of video recording per se. This emotional response has been well documented in the literature where those who experienced recording of clinical practice, be it real clinical interaction or in simulation, have expressed feeling of stress, judgement, humiliation, anxiety, loss of privacy and dignity and a sense of guilt and shame (Hunukumbure, Smith, & Das, 2017; Iedema et al., 2009

; Mir, Evans, Marshall, Newcombe, & Hayes, 1989; Parry et al., 2016; Woolrych et al., 2015)It is therefore essential to engage with participants and stakeholders in the recording process prior to implementation. Not only will this augment the engagement and 'buy in' identified as important in the *open communication* theme but it will also help to identify and limit hitherto unexpected problems through an enhanced understanding of the point of view of those involved (Borg, 2021). By preparing, informing, reassuring and listening to those subjected to the use of a VMS it may be possible to avoid, or at least reduce, the negative emotions often reported or expected prior to the use of video recording processes. However, there is also the clear indication that often these negative emotions are more anticipatory than a reflection of the reality of the actual experience of being subject to video recording. Lindon-Morris and Laidlaw (2014), for example, found that the student participants in their study expressed anxiety at the prospect of being recorded, however by the conclusion of the process reflected positively and identified the benefits of the process. Other authors have reported a similar reduction in anxiety and other negative emotions once actual experience with the recording process has occurred (Beam et al., 2014; Nilsen & Baerheim, 2005; Parker, Farrell, Bethune, Hodgetts, & Mattick, 2019). This effect was also noted in the Study 2 trial participants, who, while admitting to initially feeling anxious, reported quickly losing awareness of the recording process and ultimately of seeing the advantages of the approach.

While familiarity with and experience of the process of video-based monitoring systems can clearly reduce the fear associated with the use of such approaches, HCWs can still fear that any recorded practice could be judged, particularly by those in positions of power (Iedema, Long, Forsyth, & Lee, 2014). When asked to consider how the use of a VMS differed from having practice observed by a human observer, study participants alluded to the permanent, accurate and unambiguous evidentiary nature of video footage. That is, the situation transformed from recollection to certainty due to what Iedema et al. (2014) refer to as "the power of the visual evidence" (p. 165).

Another example of the interconnected nature of the themes surrounding acceptability is the relationship between the need to make HCWs feel safe in relation to the fears of punitive consequences resulting from the use of VMS for auditing and the impact of *the how and when of feedback*. Essentially HCWs and to a lesser extent, consumers, fear negative consequences as a

result of their behaviours, skills and/practice being observed. Fears range from simple embarrassment and loss of face through to deregistration and dismissal. While the use of video-based modalities appears to amplify the fear, it is clear that it cannot be considered the absolute cause of that fear. It is worth considering the negative emotions reported as being associated with direct observation and feedback related to that process was also repeatedly brought up by participants across all three studies. What this may suggest is that many HCWs, indeed many humans, find the self-confrontation enforced by the observation of their practice and the subsequent provision of feedback, be it immediate and verbal or video-based, unpleasant and uncomfortable. It just may be more so when video is utilised. The evidentiary impact is impossible to dismiss as merely the auditor's opinion. In addition, building upon the identification and feedback of practice deficits, is the anticipation of adverse consequences. As has been repeatedly expressed by participants, there is a genuine though perhaps largely unrealistic fear that as a consequence of something captured by a VMS, an unpleasant outcome will result.

Across the studies reported in this work, HCW participants have expressed fear and discomfort relating not only to the receipt of feedback about potential practice deficits, but also in relation to anticipated outcomes as a consequence of that feedback. The presence of a visual record and the inherent unambiguous proof that it would provide, is only likely to exacerbate these concerns as compared to similar mistakes detected by direct observation. It is unfortunate that there seems to exist an expectation of punishment or 'getting into trouble' reported by many participants, many times throughout this work. Throughout the literature are recommendations for the importance and benefit of a supportive, open, positive, no-blame, safety focused culture in healthcare where feedback is welcomed and mistakes are treated as opportunity to learn and improve (Care, 2012; Gelbart et al., 2009; van Dalen et al., 2019; Wu et al., 2017).

SUMMARY

This study demonstrates the utility of VMS for the collection of hand hygiene data according to the WHO 5 Moments. VMS can be an accurate, efficient and effective data collection approach, which can be further utilised to inform and focus education, improvement and behaviour change programs. As has been noted, video-based systems have several important advantages as compared to many of the electronic compliance monitoring approaches reported.

This study makes an original contribution to the literature and adds to the results of the systematic review by Wang et al. (2021) which identified 73 studies involving the implementation of electronic monitoring for hand hygiene compliance published between 2009 and 2020. Of these only 10 involved the use of cameras (9 separate studies) and only 3 were able to describe data collection

consistent with the WHO 5 Moment criteria as distinct from proxy measures. One study (Diefenbacher et al., 2020) involved the use of chest mounted cameras and was able to capture practice according to the WHO 5 Moments criteria and the HCW track or journey through the clinical space. The remaining 2 studies were the works of Sanchez-Carrillo et al. (2016) and Diller et al. (2014) which, while capturing within-zone hand hygiene according to the 5 Moment criteria, lacked sufficient camera density to obtain the full picture of HCW hand hygiene behaviour.

As evidenced in a study by Dyson and Madeo (2017), there are four major advantages that video-based systems have over the alternative approaches that dominate the sphere of electronic monitoring systems for hand hygiene compliance. First, the ability to monitor hand hygiene according to the WHO 5 Moments criteria rather than proxy measures such as room entry/exit. Second, with VMS there is no requirement for HCWs to change their behaviour or work flows, for example, scan their hands or use only a certain number of restricted hand hygiene product dispensers. Third, HCWs are not prompted to perform unnecessary hand hygiene, nor are they subject to alarms which they will eventually ignore. Finally, video-based systems are not subject to 'gaming' where HCWs artificially modify their behaviour to achieve a score according to system compliance rather than necessarily following best practice according to the WHO 5 Moments for hand hygiene framework. These advantages serve to crystallise and confirm the potential for video-based monitoring to enable the collection of accurate hand hygiene compliance data consistent with the WHO 5 Moments. Whilst the technical capacity to record practice has been demonstrated in the literature (Brooks et al., 1999; Clack et al., 2017; Diller et al., 2014; Haac et al., 2017) questions still remained as to whether such an approach would prove accurate, efficient, cost-effective and perhaps, most importantly, acceptable to healthcare workers and patients. The exploration of these questions have been the key focus of this study and it is clear that further exploration of the topic is warranted. Chapter 6 provides a summative conclusion to this work, as well as making suggestions for the direction of future research upon the topic.

CHAPTER 6: CONCLUSIONS

This final chapter concludes the thesis and the research study. First, it returns to the background, problem, purpose and aims of the study. It then provides a summary of the key findings, followed by a critique of the research methods employed. The chapter, and thereby the thesis, concludes with the implications of the study in four key areas.

BACKGROUND AND PURPOSE OF THE STUDY

Optimal hand hygiene practice is vital for high quality and safe patient care. The current gold standard method of assessing compliance is direct observation. As examined in earlier chapters and reinforced by participants in this study, direct observation has limitations including being time and resource intensive, particularly in terms of human capital. It also results in small samples, which capture only a fraction of overall hand hygiene behaviours, and which are subject to a variety of biases, including selection bias, observer bias and perhaps most notably, the Hawthorne Effect.

As revealed in Chapter 2, existing electronic-based approaches proposed as solutions to the issues associated with direct observation have not demonstrated utility in terms of auditing hand hygiene compliance according to the WHO 5 Moments framework, relying instead upon proxy measures. Video-based monitoring systems have, however, shown potential, but have up to this point only been reported in a limited manner.

The aim of this doctoral study was to explore the utility of video-based methods for contemporary hand hygiene auditing. This question was answered though 3 interconnected studies. First, the study examined what technical and methodological specifications might be required for a video-based approach to contemporary hand hygiene auditing. Second, it examined the effectiveness, efficiency and accuracy of video-based monitoring systems for contemporary hand hygiene auditing. And third, it explored HCW and consumer attitudes towards a video-based surveillance method of hand hygiene auditing.

SUMMARY OF THE KEY FINDINGS

This study makes an original and significant contribution to the literature as to the utility of VMS for auditing hand hygiene compliance. It has determined, through a systematic and methodological exploration comprising three linked studies, that VMS has utility for the auditing of hand hygiene compliance according to the WHO 5 Moments.

With respect to the technical and methodological specifications that might be required for a VMS able to collect data for subsequent auditing according to the WHO 5 Moment framework, this study revealed a number of inclusions that participants identified as being required in order to collect data to allow auditing according to the WHO 5 Moments framework. At the same time, themes emerging from the participant interviews highlighted the need for a VMS to operate within a framework that maintained a sense of safety and privacy and was hence, acceptable to all stakeholders. Technical features identified included proximity activation of cameras, rear or overhead camera placement, facial pixilation and secure data storage. Methodological features which would enhance the acceptability of the method while still allowing appropriate data capture included clarification of the legal, privacy and consent implications of the use of VMS for hand hygiene auditing, codification of the feedback process and assurances of the confidential and non-punitive handling of the recorded footage.

These technical and methodological specifications informed a proof-of-concept trial in simulation of the utility of VMS with respect to its efficacy, efficiency and accuracy. Six simulation scenarios were conducted and recorded using several different VMS methods. The data were audited according to the WHO 5 Moment framework and using the NHHI tools routinely employed for direct observational auditing. Utility of the approach was demonstrated via the ability to audit the recorded footage according to the WHO framework and moreover to do so in an accurate, effective and efficient manner. This was primarily due to the ability to conduct the auditing in a quiet and disturbance free environment, the capacity to rewind and pause the footage, and the ability to have the results of the auditing verified by one or more other auditors. This functionality provided greater certainty as to the analysis and hence promoted accuracy in auditing. Efficiency in footage review was achieved via the ability to track the participants from camera to camera so that the entire hand hygiene journey was captured, while the fast forward functionality increased the speed of review meaning that auditing occurred in just over half the time as compared to the duration of the scenario.

Having established the utility of VMS to audit hand hygiene compliance, the Study 3 explored the acceptability of the approach to HCWs and patients. This was on the basis that although the technical capacity to collect data using a VMS was demonstrated, HCW and patient attitudes have the potential to act as a barrier to use if the approach is deemed unacceptable, as was identified in the literature review and in Study 1. In the study, the concept of acceptability of VMS for auditing hand hygiene compliance was explored via group interviews with trial participants and online surveys and interviews with patients and HCW and was deemed broadly acceptable. This acceptability was based on 5 interrelated themes that canvassed a range of caveats and conditions

upon which the overall acceptability of VMS for hand hygiene auditing was based for the study participants. These themes included protecting *patient privacy, making HCWs feel safe, open communication, the how and when of feedback* and *better data, better feedback, better care*. Core to acceptability by HCW and patients were regulatory matters such as legislation, policy and procedures as well as privacy, consent and the status of the footage.

CRITIQUE AND LIMITATIONS OF THE RESEARCH METHOD AND THE STUDY

Determining the utility of video-based methods for contemporary hand hygiene auditing was achieved through 3 interconnected studies. Study 1 undertook an initial assessment of what technical and methodological features might be required in a VMS for hand hygiene auditing to collect and analyse data relating to hand hygiene behaviours relative to compliance with the WHO 5 Moments. Study 1 included a comprehensive, in-depth narrative analysis of the literature rather than a systematic review per see. Although it is acknowledged that this may be considered a limitation of the work and the results need to be viewed via this lens, the review was both critical and comprehensive and resulted in publication [Appendix 1]. . Study 1 also incorporated interviews with key informants. Interview participants were recruited purposely and voluntarily and hence, were selected for their expertise and ability to inform the data collection rather than as a random sample, which is a typical practice in qualitative studies where participants are recruited on the basis that they are useful informants and can help to provide understanding of the problem under investigation (Forman et al., 2008). As has been described in Chapter 3, participants were primarily content experts, managers of data who were largely IPAC professionals or were frontline hand hygiene auditors. Participants were from a relatively broad range and type of practice settings, including most states of Australia as well as metropolitan, rural and regional settings. It is possible that recruitment should have also included non-auditor frontline HCWs in this phase of the data collection as the responses of those subject to the use of a VMS may have been significant. An alternative view is that without the sample footage used in Study 3 to demonstrate the approach, informed responses may have been problematic. Data saturation occurred in the Study 1 data collection and the themes which emerged, when combined with the evidence and information from the literature review provided technical and methodological specifications for the approach used in the Study 2 trial.

Study 2 was a highly detailed and sophisticated simulation trial. It involved the application of the results of Study 1 and a trial of a VMS to audit hand hygiene compliance according to the WHO 5 Moment criteria in addition to gathering insights into the effectiveness, efficiency and accuracy of the approach. The trial participants were aware that auditing of hand hygiene compliance was the

aim of the study and as a consequence could not fail to have a heighted consciousness with regard to their practice, meaning that they were more likely to follow correct practice. This was not germane, however, as the aim was not to measure the hand hygiene compliance per see, rather it was to establish whether it was possible to audit hand hygiene compliance according to the WHO 5 Moments. Hence, the compliance percentage was in and of itself not relevant to the study aim. In addition, while Study 2 provided evidence of utility of VMS in terms of feasibility and time efficiency in simulation, further research is required to examined utility in actual clinical context. In particular, while time efficiency translated to improved cost efficiency in terms of comparative cost to audit as described in Chapter 4 consideration was not given to the additional expenses inherent in either direct observation or the use of a VMS such as capital infrastructure, installation and maintenance expenses for the latter and opportunity costs with regard to the former. It is also acknowledged that data collection for study 2 comprised a proof of concept trial in simulation rather than a clinical setting, this was a deliberate strategy as this work represents a pilot of the approach and hence the limitation was a necessary part of the development process. It is contended that this research has laid the foundations for an in vivo trial in a "real life" clinical setting however the limitation of the result is recognised in this context.

Study 3 explored the acceptability of VMS for patients and HCWs. Data collection was via group interviews with Study 2 trial participants, online surveys and follow-up interviews with key informant HCWs and patients. The survey tool underwent a single round of pilot testing as a face validity check. Minimal issues and revisions were identified and hence subsequent pilot testing was not pursued. It is acknowledged that this could be considered a limitation of the sampling approach. Survey responses were low in number particularly where patients were concerned. This was attributed to a number of factors. The first was that invitation and encouragement to participate was by necessity mediated by various organisations and hence, it is unclear how and how well the study was promoted. In addition, the overall study including the Study 3 survey in particular, took place during the height of the COVID-19 pandemic in Australia, including periods of lockdown when many HCWs were both overworked and likely experiencing survey fatigue, which may also have accounted for the comparatively poor response rate and certainly contributed the difficulties at a practical level of recruitment. Nonetheless the survey responses were helpful and provided a useful means of triangulation to the rich data collected via interview. Interview data collection for Study 3 was via a convenience sample of voluntary participants selected for their ability to provide rich data and support the answering of the study question. It was limited to those who speak English and although several were from a non-English speaking background, all were sufficiently fluent in the language to be able to engage with and understand the interview process. It would be important to

consider the reaction of vulnerable and non-English speaking populations to the use of video-based auditing in healthcare as part of any implementation process. It is acknowledged therefore that the participants may not embody a representative sample of either the overall HCW or healthcare patient population. However, participants provided rich data relating to the acceptability of the use of VMS for hand hygiene auditing with strong and consistent themes emerging. Although it is not intended as a universal truth, the outcomes from this study reported in Chapter 4 and discussed in Chapter 5 have provided a foundation for further exploration of the topic.

Overall, the 3 studies which comprise this doctoral thesis took place within an Australian healthcare context with participants drawn from a range of settings including all states of Australia, metropolitan, rural and regional health and both the public and private sectors. HCW participants practiced in a range of settings including acute inpatient, residential aged care and ambulatory healthcare. They had been practicing for anywhere from less than a year to more than 40 years. The data collection parameters mean that results of the study may not be generalisable or transferable beyond the socio-cultural context within which it occurred and hence it will be important to explore whether the findings can be applied in other situations, with differing cultural contexts, patient and HCW populations and systems of healthcare.

IMPLICATIONS OF THE STUDY

The findings from this study have implications in four areas. First, the practice of hand hygiene auditing. Second, regulation, legislation, guidelines, policy and procedure which will need to be considered, reviewed and amended or even be specifically written in order to take into account the use of VMS in the clinical setting. Thirdly, there will be implications for communication, education, and professional development and finally there is potential for future research regarding the application of VMS in the clinical setting.

For the Practice of Hand Hygiene Auditing

The aim of this study was to explore the utility of a VMS as a method for hand hygiene auditing. This study and the thesis demonstrate the utility of VMS for hand hygiene auditing and add to the body of literature related to the use of electronic monitoring systems for auditing hand hygiene compliance, specifically the use of VMS, regarding which there is a paucity of data at this time. Suitably designed VMS show the potential to collect data in a format appropriate for auditing according to the WHO 5 Moments criteria. In addition, it may be possible that data collected using a VMS could be considered valid for submission under the auspices of the NHHI and hence the potential to utilise the approach in this manner is another area to be examined and explored.

Further, it has been demonstrated that a video-based approach appears promising with regard to the collection of such data with efficiency, efficacy and accuracy. The time savings inherent in the collection and analysis of hand hygiene compliance data via a VMS would suggest the potential for economic benefit, although at this stage this is not absolute and is hence another area for further investigation. The literature and the responses by study participants would suggest that data collected via a VMS is less impacted by a variety of biases, most notably the Hawthorne Effect. The implications of this improved validity and reliability in terms of data quality means that the scope and scale of any practice gaps could be identified, targeted remedial strategies could be developed, implemented and through repeat auditing assessed for efficacy, ultimately leading to improved quality and safety of patient care.

It is argued that if one intends to implement any new process or practice it is important to understand and be clear as to the aim of both it and the status quo (Jacobs et al., 2010). This would mean having a clear understanding of what is trying to be achieved through the use of both the method of direct observational auditing and of a VMS in relation to the auditing of hand hygiene compliance. The analyses of the responses from participants in this study show that there is a distinct lack of certainty as to what an auditor is trying to achieve when present in the clinical environment conducting direct observational auditing. The setting of compliance targets by the former NHHI, which health services are required to meet, would suggest that collecting accurate data regarding hand hygiene compliance in order to subsequently assess achievement of those targets, is the aim of the process. However, to quote the NHHI Hand Hygiene Manual:

> *"It is imperative that a hand hygiene program is not only about collection of hand hygiene audit data. To ensure culture change and improved hand hygiene behaviours of healthcare staff, a hand hygiene program must include appropriate access to hand hygiene facilities, training and education, promotion, auditing and feedback of results as a minimum. All components are equally important to achieve lasting changes." (ACSQHC, 2019) Section:1.7.4 Ensuring culture change*

While the above ratifies the idea that accurate data collection is not the only aim, it is clear from the literature and was endorsed by the responses of numerous participants from auditor to consumer alike, that in terms of collecting compliance data relative to normal practice, direct observational auditing is lacking. Jeanes et al. (2015) make this point when they question the validity of direct observation as a data collection method in their pithily titled paper, *Collecting the data but missing the point*. Participants in all 3 studies indicated that they felt that the compliance rate collected and subsequently submitted under the auspices of the NHHI could not be considered to accurately

represent the reality of HCW practice when no auditing is occurring. In particular, participants highlighted the impact of the presence of the human auditor on HCW behaviours as artificially elevating compliance and causing what Borg (2021) describes as “staged performances rather than naturalistic observations” (p. 4). Hence, it could be argued that there seems to be a great deal of ambiguity and confusion as to what it is that is aiming to be achieved via the current practice of direct observational auditing and that moving forward, it will be important to clarify the aim of these practices.

It is important to consider the results of this study in line with existing methods for hand hygiene auditing, namely direct observation. The literature and the evidence from this study indicate the chief advantages of direct observation should lie in the ability to provide immediate feedback and education and to actively promote hand hygiene compliance. Indeed, the provision of feedback has been recommended from the outset as a pivotal part of the WHO 5 Moments approach (Sax et al., 2009a). It is contended that while this may indeed be the potential for the approach, participants in this study suggested that feedback is comparably rare, of questionable quality, unwelcome in the midst of the clinical day and as a consequence likely to be ineffective. As Kruger (1999) argues, the provision of negative feedback is not something that typically occurs in “everyday life” (p. 1131) thus suggesting that the practice goes against societal norms. They also contend that those who lack the competence to undertake an activity correctly may also lack the competence to understand the feedback they receive and take advantage of it to correct or improve their practice. Auditors who participated throughout this study also spoke of negative responses to feedback on numerous occasions and a clear reluctance to both audit and provide feedback was evident. It is important that HCWs constantly strive to improve the quality and safety of healthcare. All too often in the midst of a busy and at times overwhelming clinical milieu, HCWs cannot always recognise when their practice falls short or when things could be improved. This reinforces the need for skilled and quality improvement focused feedback which is consistent with the findings of A. J. Stewardson et al. (2016) and Fuller et al. (2012) who were able to show that enhanced performance feedback had a positive effect on hand hygiene compliance. This raises the possibility and the need to further explore the potential role of VMS as part of the feedback process. The potential to use recorded footage to provide powerful and contextual feedback on hand hygiene behaviours was raised by study participants and is consistent with video reflexive practices which have been demonstrated to be beneficial (Hor et al., 2017; Iedema et al., 2015; Wyer et al., 2015).

It is important to be clear that this study was not based on the premise of the wholesale abandonment of direct observation. Nor does it in any way advocate for this. Rather, it is suggested, and subsequently found, that VMS has utility in hand hygiene auditing to collect and analyse data in

an accurate, effective and efficient manner that is also acceptable to HCWs and patients. The future implications of these results may be the potential to use a VMS alongside direct observational auditing in a form of hybrid approach to the practice of hand hygiene auditing. In this context direct observation could take on the role of a driver of behaviour change and practice improvement via the provision of immediate or 'just in time', positive, skilled and supportive feedback and education in the clinical setting. The results of this study are consistent with the literature in that the collection of less bias impacted picture of hand hygiene compliance could be the remit of a VMS. This contention is supported by the literature (Daniels, 2012; D. J. Gould et al., 2017) and was also repeatedly stressed by study participants who reported that they believed that they would quickly forget the presence of cameras leading to the capture of more naturalistic practice.

Future work should also focus on the trial of a suitable VMS in tandem with direct observation and in a variety of clinical settings rather than in simulation, as has been noted and will be discussed. Accurate hand hygiene compliance data collected via the use of a VMS could assist in the development of a realistic picture of HCW behaviour in the clinical setting and allow for the identification of risks to patient safety due to practice gaps. It could also allow for the focused targeting of practice change programs via the direct observational approach to address more specifically any areas of need thus identified.

Having expressed the potential utility of VMS as a part of the process of hand hygiene auditing, it will be important to consider the regulatory frameworks within which it would operate, as will be discussed next.

For Regulation, Legislation, Guidelines, Policy and Procedure

This study has demonstrated the technical utility of VMS to capture HCW-patient interactions, to subsequently audit hand hygiene compliance with accuracy, efficacy and efficiency and moreover to do so in a way that is generally acceptable to HCWs and patients. In doing so, it revealed the need for enabling regulation, including legislation and policy. While some aspects of the use of a VMS would be covered by various existing legislation there are several areas which are ambiguous, and others that do not appear to be covered by mandate at all. As a part of the themes which emerged from Study 3, the need for clarity and communication surrounding issues such as the status of hand hygiene auditing relative to the Privacy Act (Australian Parliament, 2014; Commonwealth, 1988) and various surveillance device legislation (Government of South Australia, 2019; Parliament of South Australia, 2016) was made clear by participants. In addition, illumination and further clarification of the rules and requirements relating to the status of VMS data, whether it is a part of the patient record or not and the consequent constraints on data retention, storage and

deletion will need to be clarified as the current legislation and standards are not explicit in the matter (Australian Standard, 2006; Commonwealth, 2016; Government, 2020 Update). Consent is another area that will need clarification and likely legislation to guide practice. As things stand it would appear that the status attributed to data collection via a VMS, be it as a permitted health situation as described in the Australian Privacy Principles (Australian Parliament, 2014), a quality improvement activity or an audit (NHMRC, 2014) will determine what is required in terms of consent. Although many participants in this study advocated an opt-out approach to consent, this would need to be ratified or codified via formal regulation. As was noted by Le Bris et al. (2020), specific legislation to cover the various aspects of the use of video recording in the healthcare setting, and specifically the hand hygiene auditing context, will most likely be required.

In addition to national or state-based legislation, local healthcare networks and facilities will also need to provide guidance to how VMS would be managed at a local level. Most, if not all healthcare institutions undoubtedly already use CCTV and other similar video technology in both public and operational areas, along with a variety of other vision-based monitoring approaches and will have appropriate regulation to support and enable this. At the current time, however, the use of within patient zone cameras, in particular for hand hygiene auditing will not be supported by a regulatory framework. This will mean that that there will be the need to amend or develop, guidelines, policies and/or procedures based upon state and national legislation but aligned to the individual practice context. Such policies may need to give consideration to the more specific details highlighted by the participants in this work. These may include local data storage, confidential auditing and feedback practices, management of detected noncompliance and the process for open disclosure of any recorded sentinel or adverse events.

It will be essential that the policy, procedure and legislative status relating to the use of VMS be communicated to all stakeholders as will be discussed next.

For Communication, Education and Training

In the Australian context, the practice of monitoring and reporting hand hygiene compliance in healthcare falls under the National Safety and Quality Health Service Standards (Australian Commission on Safety and Quality in Health Care, 2017) which have been produced by the Australian Commission on Safety and Quality in Health Care (ACSQHC). The aim of ACSQHC is to achieve a safe, high-quality and sustainable health system and a part of this process was the establishment of the NHHI in 2008 to reduce the incidence of HAIs. According to the National Standards all health services are required to have a hand hygiene program that is consistent with the current NHHI, as well as jurisdictional requirements and includes contingencies to address any

detected noncompliance or inconsistency (Australian Commission on Safety and Quality in Health Care, 2017). The current NHHI mandate for the collection of hand hygiene compliance data is for the use of direct observation (Grayson, Havers, Ryan, & Olsen, 2018b). Communication and discussion with the ACSQHC and the NHHI would therefore be required as a part of any exploration of the use of VMS for hand hygiene auditing, particularly if submission of Moments collected via VMS was to be considered as a part of the national auditing process. In addition, given the origin of the 5 Moments framework and the recommendation of the use of direct observation originates with the WHO, consideration should also be given to involving this body in discussion and exploration of the use of VMS for hand hygiene auditing.

Open communication was a factor participants reported as being important for the acceptability of VMS for hand hygiene compliance. Related to this were the fears expressed by healthcare workers resulting from the use of a VMS. It would therefore be an integral part of any pre-implementation process that there was extensive communication with key stakeholders.

For HCWs, forums where information and education could be provided, concerns listened to and addressed and reassurances given would be an important step in the development and eventual further implementation and acceptance of the approach in healthcare. Study participants expressed the importance of transparency with regard to the purpose of VMS, as well as how the system would work at a practical level and how the resultant output data would be managed, stored and deleted. All of these aspects would need to be clearly communicated to those subject to the use of a VMS.

The recent COVID-19 global pandemic has highlighted the importance of hand hygiene and other related infection prevention behaviours in the minds of the general public; however, many will not fully appreciate the nuances of these practices. Most patients, however, will not appreciate that hospitals are not necessarily always safe and that at times practice can fall short. Therefore, education and information for the public will be needed to explain not only how a VMS would operate, but also why and to what benefit in terms of improved quality and safety in healthcare.

Professional development, education and communication would also be needed for hand hygiene auditors who would be required to undertake auditing using the VMS output footage. Although auditing from the footage takes place according to the same WHO 5 Moments criteria as does direct observation, auditors may require education regarding the use of the VMS technology at a practical level. In addition, clarification of confidential management of the footage, the process of feedback using the footage, the management of HCWs who refuse to engage with the feedback process, including any escalation processes and the procedure for handling any observed poor

practice or sentinel events would have to occur and auditors assisted to adapt to a different auditing practice.

For Future Research

This study was the first trial of a VMS in this framework and more research is needed. Furthermore, this study was conducted in an Australian setting and utilised a proof-of-concept trial in simulation. Future investigation will need to focus on trials in actual clinical settings of a variety of types to test the generalisability of the approach to various practice contexts.

Further explorations of video-based technology will also be warranted. Various camera and recording options can be explored, as well as the adjunct review software. As was noted above artificial intelligence, pattern recognition and machine learning (Chan, 2022 - prepublication; Nguyen-Duc, 2022) offer exciting possibilities in conjunction with the systems trialled in the current work. Hence, the explorations of further technical developments show exciting promise to further refine and improve the general model described in this work.

In addition to an exploration of the various technologies available to capture hand hygiene compliance data, there also exists the potential to investigate putting both the camera infrastructure and the resultant data to a variety of uses. This was touched upon briefly in Studies 2 and 3 but was beyond the scope of the current study to fully explore. Cameras are increasingly common in the healthcare setting and are being put to a variety of uses. Similarly, participants identified the increasing use of CCTV in the wider public sphere. Therefore, it is suggested that the investigation of putting within-zone cameras to multiple uses in addition to hand hygiene, such as patient behaviour and fall monitoring, telehealth consultations including family meetings and staff safety could be explored through suitably designed studies. Further, there is also potential for the output from a VMS to be used for additional practice improvement activities including auditing of ANTT, TBP and numerous other procedure-based assessments in addition to hand hygiene and hence, further investigation of these possibilities should also be considered.

CONCLUSION

Hand hygiene is vital for high quality and safe healthcare. How it is we know the hand hygiene behaviours of healthcare workers and others is correct and can be verified was at the heart of this study. There are clear advantages to direct observation as the current gold standard method of hand hygiene auditing. However, there are also limitations to this approach. This study has demonstrated the utility of VMS for hand hygiene compliance auditing, offers original insights into important technical and methodological considerations of such systems, and understandings as to

the acceptability of the process to HCW and patients. In doing so, the thesis makes an original contribution to the science and evidence of hand hygiene compliance auditing and the role VMS can have therein. It foregrounds further research to investigate and develop the use of VMS in a variety of settings as a useful tool to measure, and consequently improve, the hand hygiene practice of healthcare workers.

REFERENCES

ACIPCLIST. (2018). Hand Hygiene Debate in the UK Parliment. Discussion List Retrieved from http://aicalist.org.au/scripts/wa.exe?INDEX&X=B831249B162AB7AAA5&Y=katmckay68%40gmail.com

ACSQHC. (2019). National Hand Hygiene Initiative Manual. In. Sydney: Australian Commission on Safety and Quality in Health Care.

Al Salman, J. M., Hani, S., de Marcellis-Warin, N., & Isa, S. F. (2015). Effectiveness of an electronic hand hygiene monitoring system on healthcare workers' compliance to guidelines. *J Infect Public Health, 8*(2), 117-126. doi:10.1016/j.jiph.2014.07.019

Albanese, M. A. (2000). Challenges in using rater judgements in medical education. *J Eval Clin Pract, 6*(3), 305-319. doi:10.1046/j.1365-2753.2000.00253.x

Albright, J., White, B., Pedersen, D., Carlson, P., Yost, L., & Littau, C. (2018). Use patterns and frequency of hand hygiene in healthcare facilities: Analysis of electronic surveillance data. *Am J Infect Control, 46*(10), 1104-1109. doi:10.1016/j.ajic.2018.04.205

Allegranzi, B., Tartari, E., & Pittet, D. (2021). An Important Announcement from the World Health Organization: "Seconds Save Lives-Clean your Hands": The May 5, 2021, World Health Organization SAVE LIVES: Clean Your Hands campaign. *Infect Control Hosp Epidemiol, 42*(5), 649-651. doi:10.1017/ice.2021.93

Alper, P. (2015). Letter in response to "Automated and electronically assisted hand hygiene monitoring systems: a systematic review". *Am J Infect Control, 43*(2), 195-196. doi:10.1016/j.ajic.2014.08.022

Andersen, C., & Adamsen, L. (2001). Continuous video recording: a new clinical research tool for studying the nursing care of cancer patients. *J Adv Nurs, 35*(2), 257-267. doi:10.1046/j.1365-2648.2001.01842.x

Arai, A., Tanabe, M., Nakamura, A., Yamasaki, D., Muraki, Y., Kaneko, T., . . . Ito, M. (2016). Utility of electronic hand hygiene counting devices for measuring physicians' hand hygiene adherence applied to outpatient settings. *Am J Infect Control, 44*(12), 1481-1485. doi:10.1016/j.ajic.2016.08.002

Armellino, D., Hussain, E., Schilling, M. E., Senicola, W., Eichorn, A., Dlugacz, Y., & Farber, B. F. (2012). Using high-technology to enforce low-technology safety measures: the use of third-party remote video auditing and real-time feedback in healthcare. *Clin Infect Dis, 54*(1), 1-7. doi:10.1093/cid/cir773

Armellino, D., Trivedi, M., Law, I., Singh, N., Schilling, M. E., Hussain, E., & Farber, B. (2013). Replicating changes in hand hygiene in a surgical intensive care unit with remote video auditing and feedback. *Am J Infect Control, 41*(10), 925-927. doi:10.1016/j.ajic.2012.12.011

Australian Commission on Safety and Quality in Health Care. (2017). National Saftey and Quality Health Service Standards. In (2nd ed.). Sydney, NSW, Australia: Australian Commission on Safety and Quality in Health Care.

Australian Parliament. (2014). *The Australian Privacy Principles*. Australia: Australian Government Retrieved from file:///D:/Documents/PHD/Journal%20Articles/the-australian-privacy-principles%20-%202014.pdf.

Australian Standard. (2006). Closed circuit television (CCTV) Management and operation. In (Vol. AS 4806.1—2006). Australia: Standards Australia.

Azim, S., Juergens, C., Hines, J., & McLaws, M. L. (2016). Introducing automated hand hygiene surveillance to an Australian hospital: Mirroring the HOW2 Benchmark Study. *Am J Infect Control, 44*(7), 772-776. doi:10.1016/j.ajic.2016.02.012

Azim, S., & McLaws, M. L. (2014). Doctor, do you have a moment? National Hand Hygiene Initiative compliance in Australian hospitals. *Med J Aust, 200*(9), 534-537. doi:10.5694/mja13.11203

Beam, E. L., Gibbs, S. G., Hewlett, A. L., Iwen, P. C., Nuss, S. L., & Smith, P. W. (2014). Method for investigating nursing behaviors related to isolation care. *Am J Infect Control, 42*(11), 1152-1156. doi:10.1016/j.ajic.2014.08.001

Beckmann, C., Lipscomb, C., Ling, F., Beckmann, C., Johnson, H., & Barton, L. (1995). Computer-assisted video evaluation of surgical skills. *Obstetrics & Gynecology, 85*(6), 1039-1041. doi:10.1016/0029-7844(95)00068-3

Berridge, C., Halpern, J., & Levy, K. (2019). Cameras on beds: The ethics of surveillance in nursing home rooms. *AJOB Empir Bioeth, 10*(1), 55-62. doi:10.1080/23294515.2019.1568320

Berthelot, J. M., Le Goff, B., & Maugars, Y. (2011). The Hawthorne effect: stronger than the placebo effect? *Joint Bone Spine, 78*(4), 335-336. doi:10.1016/j.jbspin.2011.06.001

Bird, C. M. (2016). How I Stopped Dreading and Learned to Love Transcription. *Qualitative Inquiry, 11*(2), 226-248. doi:10.1177/1077800404273413

Blank-Reid, C. A., & Kaplan, L. J. (1996). Video Recording Trauma Resuscitations. *Journal of Trauma Nursing, 3*(1), 9-12. doi:10.1097/00043860-199601000-00008

Borg, S. (2021). Video–based observation in impact evaluation. *Evaluation and Program Planning, 89*. doi:10.1016/j.evalprogplan.2021.102007

Boscart, V. M., Fernie, G. R., Lee, J. H., & Jaglal, S. B. (2012). Using psychological theory to inform methods to optimize the implementation of a hand hygiene intervention. *Implementation Science, 7*, 77. doi:https://dx.doi.org/10.1186/1748-5908-7-77

Boscart, V. M., Levchenko, A. I., & Fernie, G. R. (2010). Defining the configuration of a hand hygiene monitoring system. *Am J Infect Control, 38*(7), 518-522. doi:10.1016/j.ajic.2010.02.007

Boscart, V. M., McGilton, K. S., Levchenko, A., Hufton, G., Holliday, P., & Fernie, G. R. (2008). Acceptability of a wearable hand hygiene device with monitoring capabilities. *J Hosp Infect, 70*(3), 216-222. doi:10.1016/j.jhin.2008.07.008

Bouk, M., Mutterer, M., Schore, M., & Alper, P. (2015). *Use of an Electronic Hand Hygiene Compliance System to Improve Hand Hygiene, reduce MRSA, and Improve Financial Performance.* Paper presented at the ACIPC 2015, Hobart, Australia.

Boyatzis, R., E. (1998). *Transforming Qualitative Information*

Thematic Analysis and Code Development (Vol. 1). London: Sage Publications.

Boyce, J. M. (2008). Hand hygiene compliance monitoring: current perspectives from the USA. *J Hosp Infect, 70 Suppl 1*(S1), 2-7. doi:10.1016/S0195-6701(08)60003-1

Boyce, J. M. (2011). Measuring healthcare worker hand hygiene activity: current practices and emerging technologies. *Infect Control Hosp Epidemiol, 32*(10), 1016-1028. doi:10.1086/662015

Boyce, J. M. (2017a). Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. *American Journal of Infection Control, 45*(5), 528-535.

Boyce, J. M. (2017b). Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. *American Journal of Infection Control, 45*(2017), 528-535. doi:10.1016/j.ajic.016.11.029

Boyce, J. M., Cooper, T., & Dolan, M. J. (2009). Evaluation of an electronic device for real-time measurement of alcohol-based hand rub use. *Infect Control Hosp Epidemiol, 30*(11), 1090-1095. doi:10.1086/644756

Boyce, J. M., & Pittet, D. (2002). Guideline for Hand Hygiene in Health-Care Settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Infect Control Hosp Epidemiol, 23*(12 Suppl), S3-40. doi:10.1086/503164

Boyce, J. M., Polgreen, P. M., Monsalve, M., Macinga, D. R., & Arbogast, J. W. (2017). Frequency of Use of Alcohol-Based Hand Rubs by Nurses: A Systematic Review. *Infect Control Hosp Epidemiol, 38*(2), 189-195. doi:10.1017/ice.2016.247

Braun, B. I., Kusek, L., & Larson, E. L. (2009). Measuring adherence to hand hygiene guidelines: a field survey for examples of effective practices. *Am J Infect Control, 37*(4), 282-288. doi:10.1016/j.ajic.2008.09.002

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi:10.1191/1478088706qp063oa

Brooks, A. J., Phipson, M., Potgieter, A., Koertzen, H., & Boffard, K. D. (1999). Education of the trauma team: video evaluation of the compliance with universal barrier precautions in resuscitation. *Eur J Surg, 165*(12), 1125-1128. doi:10.1080/110241599750007621

Brotfain, E., Livshiz-Riven, I., Gushansky, A., Erblat, A., Koyfman, L., Ziv, T., . . . Borer, A. (2017). Monitoring the hand hygiene compliance of health care workers in a general intensive care unit: Use of continuous closed circle television versus overt observation. *Am J Infect Control, 45*(8), 849-854. doi:10.1016/j.ajic.2017.03.015

Brown, J., Friese-Fretz, A., Luckey, D., & Todd, J. K. (1996). High rate of hand comtamiation and low rate of hand washing before infant contactin a neonatal intensive care unit. *The Paediatric Infectious Disease Journal, 15*(10), 908-910.

Brown, N. A., Blake, A. B., & Sherman, R. A. (2017). A Snapshot of the Life as Lived. *Social Psychological and Personality Science, 8*(5), 592-600. doi:10.1177/1948550617703170

Broyles, L. M., Tate, J. A., & Happ, M. B. (2008). Videorecording in clinical research: mapping the ethical terrain. *Nurs Res, 57*(1), 59-63. doi:10.1097/01.NNR.0000280658.81136.e4

Burke, J. P. (2003). Infection Control — A Problem for Patient Safety. *The New England Journal of Medicine, 348*(7), 651-656.

Butler, D. J. (2018). A review of published guidance for video recording in medical education. *Fam Syst Health, 36*(1), 4-16. doi:10.1037/fsh0000328

Cantrel, S. (2016, Octber 2016). Electronic hand-hygiene systems take compliance to the next level. *Healthcare Purchsing News,* 24-29.

Care, A. C. o. S. a. Q. i. H. (2012). *Open Disclosure Standard Review Report*. Retrieved from Sydney, Australia:

Care, A. C. o. S. a. Q. i. H. (2019). National Hand Hygiene Initiative Manual. In *National Hand Hygiene Initiative Manual - October 2019, 2021 Update* (pp. 107). Sydney: Australian Commission on Safety and Quality in Health Care.

Cavanagh, S. (1997). Content analysis: concepts, methods and applications. *Nurse Res, 4*(3), 5-16. doi:10.7748/nr.4.3.5.s2

Chan, P., Tay, A., Chen, D., De Freitas, M., Millet, C., Nguyen-Duc, T., Duke, D., Lyall, J., Nguyen, J.T., Mcneil, J., Hopper, I. (2022 - prepublication). Patient Activity and Workload Monitoring in the Intensive Care using a Camera-Based Artificial Intelligence. *Journal of Clinical Monitoring and Computing*.

Chen, L. F., Carriker, C., Staheli, R., Isaacs, P., Elliott, B., Miller, B. A., . . . Sexton, D. J. (2013). Observing and improving hand hygiene compliance: implementation and refinement of an electronic-assisted direct-observer hand hygiene audit program. *Infect Control Hosp Epidemiol, 34*(2), 207-210. doi:10.1086/669084

Chen, Y. C., Sheng, W. H., Wang, J. T., Chang, S. C., Lin, H. C., Tien, K. L., . . . Tsai, K. S. (2011). Effectiveness and limitations of hand hygiene promotion on decreasing healthcare-associated infections. *PLoS One, 6*(11), e27163. doi:10.1371/journal.pone.0027163

Cheng, V. C., Tai, J. W., Chan, W. M., Lau, E. H., Chan, J. F., To, K. K., . . . Yuen, K. Y. (2010). Sequential introduction of single room isolation and hand hygiene campaign in the control of methicillin-resistant Staphylococcus aureus in intensive care unit. *BMC Infect Dis, 10*(263), 263. doi:10.1186/1471-2334-10-263

Cheng, V. C., Tai, J. W., Ho, S. K., Chan, J. F., Hung, K. N., Ho, P. L., & Yuen, K. Y. (2011). Introduction of an electronic monitoring system for monitoring compliance with Moments 1 and 4 of the WHO "My 5 Moments for Hand Hygiene" methodology. *BMC Infect Dis, 11*(151), 151. doi:10.1186/1471-2334-11-151

Cherryholmes, C. H. (1992). Notes on Pragmatism and Scientific Realism. *Educational Researcher, 21*(6), 13-17.

Cherryholmes, C. H. (1994). More Notes on Pragmatism. *Educational Researcher, 23*(1), 16-18.

Clack, L., Scotoni, M., Wolfensberger, A., & Sax, H. (2017). "First-person view" of pathogen transmission and hand hygiene - use of a new head-mounted video capture and coding tool. *Antimicrob Resist Infect Control, 6*, 108. doi:10.1186/s13756-017-0267-z

Cohen, B., Murray, M., Jia, H., Jackson, O., Saiman, L., Neu, N., . . . Larson, E. L. (2016). Is hand hygiene frequency associated with the onset of outbreaks in pediatric long-term care? *Am J Infect Control, 44*(12), 1492-1494. doi:10.1016/j.ajic.2016.06.022

Privacy Act, (1988).

Commonwealth. (2016). *Surveillance Devices Act 2016*. South Australia: Government of South Australia Retrieved from https://www.legislation.sa.gov.au/LZ/C/A/Surveillance%20Devices%20Act%202016.aspx.

Commonwealth of Australia. (2022). Office of the Australian Information Comissioner. *Access your health information.* Retrieved from https://www.oaic.gov.au/privacy/health-information/access-your-health-information

Conway, L. J. (2016). Challenges in implementing electronic hand hygiene monitoring systems. *Am J Infect Control, 44*(5 Suppl), e7-e12. doi:10.1016/j.ajic.2015.11.031

Conway, L. J., Riley, L., Saiman, L., Cohen, B., Alper, P., & Larson, E. L. (2014). Implementation and Impact of an Automated Group Monitoring and Feedback System to Promote Hand Hygiene Among Health Care Personnel. *The Joint Commission Journal on Quality and Patient Safety, 40*(9), 408-417. doi:10.1016/s1553-7250(14)40053-9

Creswell, J. W., & Creswell, J. D. (2018). *Research Design : Qualitative, Quantitative, and Mixed Methods Approaches* (5th Revised edition ed.). Thousand Oaks, United States: SAGE Publications Inc.

Cruickshank, M. (2018). ACIPC Statement: Hand hygiene auditing in Australia [Press release]. Retrieved from https://www.acipc.org.au/2018/07/04/statement-hand-hygiene-auditing-in-australia/

Curtis, S. J., Trewin, A., McDermott, K., Were, K., Clezy, K., Dempsey, K., & Walsh, N. (2022). Electronic monitoring of doffing using video surveillance to minimise error rate and increase safety at Howard Springs International Quarantine Facility. *Antimicrobial Resistance & Infection Control, 11*(1). doi:10.1186/s13756-022-01155-2

Cvach, M. (2012). Monitor alarm fatigue: an integrative review. *Biomed Instrum Technol, 46*(4), 268-277. doi:10.2345/0899-8205-46.4.268

Dagnaes-Hansen, J., Mahmood, O., Bube, S., Bjerrum, F., Subhi, Y., Rohrsted, M., & Konge, L. (2018). Direct Observation vs. Video-Based Assessment in Flexible Cystoscopy. *J Surg Educ, 75*(3), 671-677. doi:10.1016/j.jsurg.2017.10.005

Daniels, T. L. (2012). Reconsidering hand hygiene monitoring. *J Infect Dis, 206*(10), 1488-1490. doi:10.1093/infdis/jis549

Dath, D., Regehr, G., Birch, D., Schlachta, C., Poulin, E., Mamazza, J., . . . MacRae, H. M. (2004). Toward reliable operative assessment: the reliability and feasibility of videotaped assessment of laparoscopic technical skills. *Surg Endosc, 18*(12), 1800-1804. doi:10.1007/s00464-003-8157-2

Davis, C. R. (2010). Infection-free surgery: how to improve hand-hygiene compliance and eradicate methicillin-resistant Staphylococcus aureus from surgical wards. *Ann R Coll Surg Engl, 92*(4), 316-319. doi:10.1308/003588410X12628812459931

Dawson, C. H. (2015). A case study of healthcare professional views on the meaning of data produced by hand hygiene auditing. *J Infect Prev, 16*(6), 248-254. doi:10.1177/1757177415592010

Decker, A. S., Cipriano, G. C., Tsouri, G., & Lavigne, J. E. (2016). Monitoring Pharmacy Student Adherence to World Health Organization Hand Hygiene Indications Using Radio Frequency Identification. *Am J Pharm Educ, 80*(3), 51. doi:10.5688/ajpe80351

den Boer, M. C., Houtlosser, M., van Zanten, H. A., Foglia, E. E., Engberts, D. P., & Te Pas, A. B. (2018). Ethical dilemmas of recording and reviewing neonatal resuscitation. *Arch Dis Child Fetal Neonatal Ed, 103*(3), F280-F284. doi:10.1136/archdischild-2017-314191

Dhar, S., Tansek, R., Dziekan, B. A., Chevalier, T. C., Bohlinger, C. G., Fitch, M., . . . LKaye, K. S. (2010). Obsever bias in hand hygiene compliance auditing. *Infection Control and Hospital Epidemiology, 31*(8), 869-870. doi:130.194.20.173

Diefenbacher, S., Sassenrath, C., Tatzel, J., & Keller, J. (2020). Evaluating healthcare workers' hand hygiene performance using first-person view video observation in a standardized patient-care scenario. *Am J Infect Control, 48*(5), 496-502. doi:10.1016/j.ajic.2019.11.032

Diller, T., Kelly, J. W., Blackhurst, D., Steed, C., Boeker, S., & McElveen, D. C. (2014). Estimation of hand hygiene opportunities on an adult medical ward using 24-hour camera surveillance: validation of the HOW2 Benchmark Study. *Am J Infect Control, 42*(6), 602-607. doi:10.1016/j.ajic.2014.02.020

Diller, T., Kelly, J. W., Steed, C., Blackhurst, D., Boeker, S., & Alper, P. (2013). O016: Electronic hand hygiene monitoring for the WHO 5-moments method. *Antimicrobial Resistance and Infection Control, 2*(S1). doi:10.1186/2047-2994-2-s1-o16

Doron, S., Kifuji, K., Hynes, B., Dunlop, D., Lemon, T., Hansjosten, K., . . . Fairchild, D. (2011). A Multifaceted Approach to Education, Observation, and

Feedback in a Successful Hand Hygiene Campaign. *The Joint Commission Journal on Quality and Patient Safety, 37*(1), 3-10.

Downing, S. M., & Haladyna, T. M. (2004). Validity threats: overcoming interference with proposed interpretations of assessment data. *Med Educ, 38*(3), 327-333. doi:10.1046/j.1365-2923.2004.01777.x

Dufour, J. C., Reynier, P., Boudjema, S., Soto Aladro, A., Giorgi, R., & Brouqui, P. (2017). Evaluation of hand hygiene compliance and associated factors with a radio-frequency-identification-based real-time continuous automated monitoring system. *J Hosp Infect, 95*(4), 344-351. doi:10.1016/j.jhin.2017.02.002

Duncan, D. F. (2013). Content Analysis in Health Education Research: An Introduction to Purposes and Methods. *Health Education, 20*(7), 27-31. doi:10.1080/00970050.1989.10610182

Duncan, J. R., Kline, B., & Glaiberman, C. B. (2007). Analysis of simulated angiographic procedures. Part 2: extracting efficiency data from audio and video recordings. *J Vasc Interv Radiol, 18*(4), 535-544. doi:10.1016/j.jvir.2007.01.006

Dyson, J., & Madeo, M. (2017). Investigating the use of an electronic hand hygiene monitoring and prompt device: influence and acceptability. *J Infect Prev, 18*(6), 278-287. doi:10.1177/1757177417714045

Eckmanns, T., Bessert, J., Behnke, M., Gastmeier, P., & Ruden, H. (2006). Compliance with antiseptic hand rub use in intensive care units: the Hawthorne effect. *Infect Control Hosp Epidemiol, 27*(9), 931-934. doi:10.1086/507294

Edmisten, C., Hall, C., Kernizan, L., Korwek, K., Preston, A., Rhoades, E., . . . Zygadlo, S. (2017). Implementing an electronic hand hygiene monitoring system: Lessons learned from community hospitals. *Am J Infect Control, 45*(8), 860-865. doi:10.1016/j.ajic.2017.03.033

Edmond, M. B., Goodell, A., Zuelzer, W., Sanogo, K., Elam, K., & Bearman, G. (2010). Successful use of alcohol sensor technology to monitor and report hand hygiene compliance. *J Hosp Infect, 76*(4), 364-365. doi:10.1016/j.jhin.2010.07.006

El-Saed, A., Noushad, S., Tannous, E., Abdirizak, F., Arabi, Y., Al Azzam, S., . . . Balkhy, H. H. (2018). Quantifying the Hawthorne effect using overt and covert observation of hand hygiene at a tertiary care hospital in Saudi Arabia. *Am J Infect Control, 46*(8), 930-935. doi:10.1016/j.ajic.2018.02.025

Ellingson, K., Polgreen, P. M., Schneider, A., Shinkunas, L., Kaldjian, L. C., Wright, D., . . . Sinkowitz-Cochran, R. (2011). Healthcare personnel perceptions of hand hygiene monitoring technology. *Infect Control Hosp Epidemiol, 32*(11), 1091-1096. doi:10.1086/662179

Ellison, R. T., 3rd, Barysauskas, C. M., Rundensteiner, E. A., Wang, D., & Barton, B. (2015). A Prospective Controlled Trial of an Electronic Hand Hygiene Reminder System. *Open Forum Infect Dis, 2*(4), ofv121. doi:10.1093/ofid/ofv121

Elo, S., & Kyngas, H. (2008). The qualitative content analysis process. *J Adv Nurs, 62*(1), 107-115. doi:10.1111/j.1365-2648.2007.04569.x

Fakhry, M., Hanna, G. B., Anderson, O., Holmes, A., & Nathwani, D. (2012). Effectiveness of an audible reminder on hand hygiene adherence. *Am J Infect Control, 40*(4), 320-323. doi:10.1016/j.ajic.2011.05.023

Filho, M. A., Marra, A. R., Magnus, T. P., Rodrigues, R. D., Prado, M., de Souza Santini, T. R., . . . Edmond, M. B. (2014). Comparison of human and electronic observation for the measurement of compliance with hand hygiene. *Am J Infect Control, 42*(11), 1188-1192. doi:10.1016/j.ajic.2014.07.031

Fisher, D. A., Seetoh, T., Oh May-Lin, H., Viswanathan, S., Toh, Y., Yin, W. C., . . . Dempsey, M. (2013). Automated measures of hand hygiene compliance among healthcare workers using ultrasound: validation and a randomized controlled trial. *Infect Control Hosp Epidemiol, 34*(9), 919-928. doi:10.1086/671738

Forman, J., Creswell, J. W., Damschroder, L., Kowalski, C. P., & Krein, S. L. (2008). Qualitative research methods: key features and insights gained from use in infection prevention research. *Am J Infect Control, 36*(10), 764-771. doi:10.1016/j.ajic.2008.03.010

French, J. R. P., & Raven, B. H. (1959). The Bases of Social Power. In D. Cartwright (Ed.), *Studies in Social Power* (pp. 259-269). Ann Arbor, MI: Institute for Social Research.

Fries, J., Segre, A. M., Thomas, G., Herman, T., Ellingson, K., & Polgreen, P. M. (2012). Monitoring hand hygiene via human observers: how should we be sampling? *Infect Control Hosp Epidemiol, 33*(7), 689-695. doi:10.1086/666346

Fuller, C., Michie, S., Savage, J., McAteer, J., Besser, S., Charlett, A., . . . Stone, S. (2012). The Feedback Intervention Trial (FIT)--improving hand-hygiene compliance in UK healthcare workers: a stepped wedge cluster randomised controlled trial. *PLoS One, 7*(10), e41617. doi:10.1371/journal.pone.0041617

Geilleit, R., Hen, Z. Q., Chong, C. Y., Loh, A. P., Pang, N. L., Peterson, G. M., . . . de Korne, D. F. (2018). Feasibility of a real-time hand hygiene notification machine learning system in outpatient clinics. *J Hosp Infect, 100*(2), 183-189. doi:10.1016/j.jhin.2018.04.004

Gelbart, B., Barfield, C., & Watkins, A. (2009). Ethical and legal considerations in video recording neonatal resuscitations. *J Med Ethics, 35*(2), 120-124. doi:10.1136/jme.2008.024612

Ghaderi, I., Manji, F., Park, Y. S., Juul, D., Ott, M., Harris, I., & Farrell, T. M. (2015). Technical skills assessment toolbox: a review using the unitary framework of validity. *Ann Surg, 261*(2), 251-262. doi:10.1097/SLA.0000000000000520

Ghosh, A., Lacey, G., Gush, C., & Barnes, S. (2011). The impact of real-time computerised video analysis and feedback on hand hygiene practice and technique on a surgical ward. *BMC Proceedings, 5*(Suppl 6). doi:10.1186/1753-6561-5-s6-o52

Gilbert, G. L. (2014). One moment doctor! Have you forgotten hand hygiene? *Med J Aust, 200*(9), 508-509. doi:10.5694/mja14.00459

Gordin, F. M., Schultz, M. E., Huber, R. A., & Gill, J. A. (2005). Reduction in nosocomial transmission of drug-resistant bacteria after introduction of an alcohol-based handrub. *Infect Control Hosp Epidemiol, 26*(7), 650-653. doi:10.1086/502596

Gottumukkala, R., Street, M., Fitzpatrick, M., Tatineny, P., & Duncan, J. R. (2012). Improving Team Performance During the Preprocedure Time-Out in Pediatric Interventional Radiology. *The Joint Commission Journal on Quality and Patient Safety, 38*(9), 387-AP381. doi:10.1016/s1553-7250(12)38049-5

Gould, D. J., Chudleigh, J., Drey, N. S., & Moralejo, D. (2007). Measuring handwashing performance in health service audits and research studies. *J Hosp Infect, 66*(2), 109-115. doi:10.1016/j.jhin.2007.02.009

Gould, D. J., Creedon, S., Jeanes, A., Drey, N. S., Chudleigh, J., & Moralejo, D. (2017). Impact of observing hand hygiene in practice and research: a methodological reconsideration. *J Hosp Infect, 95*(2), 169-174. doi:10.1016/j.jhin.2016.08.008

Gould, D. J., Drey, N. S., & Creedon, S. (2011). Routine hand hygiene audit by direct observation: has nemesis arrived? *J Hosp Infect, 77*(4), 290-293. doi:10.1016/j.jhin.2010.12.011

Gould, D. J., Lindstrom, H., Purssell, E., & Wigglesworth, N. (2020). Electronic hand hygiene monitoring: accuracy, impact on the Hawthorne effect and efficiency. *J Infect Prev, 21*(4), 136-143. doi:10.1177/1757177420907999

Government. (2020 Update). *Health Records Act 2001*. Victoria: Parliment of Victoria.

Government of South Australia. (2019). *Workplace Surveillance Policy Directive*. South Australia: SA Health.

Grabowski, M., Lobo, J. M., Gunnell, B., Enfield, K., Carpenter, R., Barnes, L., & Mathers, A. J. (2018). Characterizations of handwashing sink activities in a single hospital medical intensive care unit. *J Hosp Infect, 100*(3), e115-e122. doi:10.1016/j.jhin.2018.04.025

Granqvist, K., Ahlstrom, L., Karlsson, J., Lytsy, B., & Andersson, A. E. (2021). Learning to interact with new technology: Health care workers' experiences of using a monitoring system for assessing hand hygiene - a grounded theory study. *Am J Infect Control*. doi:10.1016/j.ajic.2021.09.023

Grayson, M. L., Havers, S., Ryan, K., & Olsen, K. (2018a). Hand Hygiene Australia 5 Moments for Hand Hygiene. 1-125.

Grayson, M. L., Havers, S., Ryan, K., & Olsen, K. (2018b). Hand Hygiene Australia 5 Moments for Hand Hygiene. In (5th ed., pp. 1-125): The Australian Commission on Safety and Quality in Health Care. (Reprinted from: 5th).

Grayson, M. L., Jarvie, L. J., Martin, R., Johnson, P. D., Jodoin, M. E., McMullan, C., . . . Hand Hygiene Statewide Roll-out Group, V. Q. C. (2008). Significant reductions in methicillin-resistant Staphylococcus aureus bacteraemia and clinical isolates associated with a multisite, hand hygiene culture-change program and subsequent successful statewide roll-out. *Med J Aust, 188*(11), 633-640.

Grayson, M. L., Russo, P. L., Cruickshank, M., Bear, J. L., Gee, C. A., Hughes, C. F., . . . Wilkinson, I. (2011). Outcomes from the first 2 years of the Australian National Hand Hygiene Initiative. *Med J Aust, 195*(10), 615-619. doi:doi: 10.5694/mja11.10747\

Haac, B., Rock, C., Harris, A. D., Pineles, L., Stein, D., Scalea, T., . . . Program, C. D. C. P. E. (2017). Hand Hygiene Compliance in the Setting of Trauma Resuscitation. *Injury, 48*(1), 165-170. doi:10.1016/j.injury.2016.08.004

Haas, J. P., & Larson, E. L. (2007). Measurement of compliance with hand hygiene. *J Hosp Infect, 66*(1), 6-14. doi:10.1016/j.jhin.2006.11.013

Haessler, S. (2014). The Hawthorne effect in measurements of hand hygiene compliance: a definite problem, but also an opportunity. *BMJ Qual Saf, 23*(12), 965-967. doi:10.1136/bmjqs-2014-003507

Haessler, S., Bhagavan, A., Kleppel, R., Hinchey, K., & Visintainer, P. (2012). Getting doctors to clean their hands: lead the followers. *BMJ Qual Saf, 21*(6), 499-502. doi:10.1136/bmjqs-2011-000396

Hagel, S., Reischke, J., Kesselmeier, M., Winning, J., Gastmeier, P., Brunkhorst, F. M., . . . Pletz, M. W. (2015). Quantifying the Hawthorne Effect in Hand Hygiene Compliance Through Comparing Direct Observation With Automated Hand Hygiene Monitoring. *Infect Control Hosp Epidemiol, 36*(8), 957-962. doi:10.1017/ice.2015.93

Hansard. (2018). *Infection Prevention and Control*. House of Commons Hansard: www.parliament.uk Retrieved from https://hansard.parliament.uk/Commons/2018-05-15/debates/395F355A-

2F8A-4175-8408-D9AB8B2AA67C/InfectionPreventionAndControl#contribution-B2EF1FF6-B01E-4BBB-A51A-3ECA1AF3D0E1.

Harbarth, S., Pittet, D., Grady, L., Zawacki, A., Potter-Bynoe, G., Samore, M. H., & Goldmann, D. A. (2002). Interventional study to evaluate the impact of an alcohol-based hand gel in improving hand hygiene compliance. *Pediatr Infect Dis J, 21*(6), 489-495. doi:10.1097/01.inf.000002551.42359.76

Harrison, R., Walton, M., Smith-Merry, J., Manias, E., & Iedema, R. (2019). Open disclosure of adverse events: exploring the implications of service and policy structures on practice. *Risk Manag Healthc Policy, 12*, 5-12. doi:10.2147/RMHP.S180359

Hassan, M., Tuckman, H. P., Patrick, R. H., Kountz, D. S., & Kohn, J. L. (2010). Cost of hospital-acquired infection. *Hosp Top, 88*(3), 82-89. doi:10.1080/00185868.2010.507124

Hayden, M. K., Bonten, M. J., Blom, D. W., Lyle, E. A., van de Vijver, D. A., & Weinstein, R. A. (2006). Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. *Clin Infect Dis, 42*(11), 1552-1560. doi:10.1086/503845

Helder, O. K., van Goudoever, J. B., Hop, W. C., Brug, J., & Kornelisse, R. F. (2012). Hand disinfection in a neonatal intensive care unit: continuous electronic monitoring over a one-year period. *BMC Infect Dis, 12*, 248. doi:10.1186/1471-2334-12-248

HHA. (2018). Hand Hgyiene Australia. https://hhcapp.hha.org.au/en_AU/HHA/dashboard

Hoang, D., Khawar, N., George, M., Gad, A., Sy, F., & Narula, P. (2018). Video didactic at the point of care impacts hand hygiene compliance in the neonatal intensive care unit (NICU). *J Healthc Risk Manag, 37*(4), 9-15. doi:10.1002/jhrm.21314

Holden, J. D. (2001). Hawthorne effects and research into professional practice. *Journal of Evaluation in Clinical Practice, 7*(1), 65-70.

Holden, R. J., & Karsh, B. T. (2010). The technology acceptance model: its past and its future in health care. *J Biomed Inform, 43*(1), 159-172. doi:10.1016/j.jbi.2009.07.002

Holloway, I., & Wheeler, S. (2010). *Qualitative Research in Nursing and Healthcare* (3rd ed.). Oxford: Wiley Blackwell.

Hor, S. Y., Hooker, C., Iedema, R., Wyer, M., Gilbert, G. L., Jorm, C., & O'Sullivan, M. V. N. (2017). Beyond hand hygiene: a qualitative study of the everyday work of preventing cross-contamination on hospital wards. *BMJ Qual Saf, 26*(7), 552-558. doi:10.1136/bmjqs-2016-005878

Hornbeck, T., Naylor, D., Segre, A. M., Thomas, G., Herman, T., & Polgreen, P. M. (2012). Using sensor networks to study the effect of peripatetic healthcare workers on the spread of hospital-associated infections. *J Infect Dis, 206*(10), 1549-1557. doi:10.1093/infdis/jis542

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qual Health Res, 15*(9), 1277-1288. doi:10.1177/1049732305276687

Hu, Y. Y., Peyre, S. E., Arriaga, A. F., Osteen, R. T., Corso, K. A., Weiser, T. G., . . . Greenberg, C. C. (2012). Postgame analysis: using video-based coaching for continuous professional development. *J Am Coll Surg, 214*(1), 115-124. doi:10.1016/j.jamcollsurg.2011.10.009

Hugonnet, S., Perneger, T. V., & Pittet, D. (2002). Alcohol-Based Handrub Improves Compliance With Hand Hygiene in Intensive Care Units. *Archives of Internal Medicine, 162*(9). doi:10.1001/archinte.162.9.1037

Hunukumbure, A. D., Smith, S. F., & Das, S. (2017). Holistic feedback approach with video and peer discussion under teacher supervision. *BMC Med Educ, 17*(1), 179. doi:10.1186/s12909-017-1017-x

Iedema, R., Hor, S.-Y., Wyer, M., Gilbert, G. L., Jorm, C., Hooker, C., & O'Sullivan, M. V. N. (2015). An innovative approach to strengthening health professionals' infection control and limiting hospital-acquired infection: video-reflexive ethnography. *BMJ Innovations, 1*(4), 157-162. doi:10.1136/bmjinnov-2014-000032

Iedema, R., Long, D., Forsyth, R., & Lee, B. B. (2014). Visibilising clinical work: Video ethnography in the contemporary hospital. *Health Sociology Review, 15*(2), 156-168. doi:10.5172/hesr.2006.15.2.156

Iedema, R., Merrick, E. T., Rajbhandari, D., Gardo, A., Stirling, A., & Herkes, R. (2009

). Viewing the taken-for-granted from under a different aspect: A video-based method in pursuit of patient safety. *International Journal of Multiple Research Approaches, 3*(3), 290-301. doi:10.5172/mra.3.3.290

Iserson, K. V., Allan, N. G., Geiderman, J. M., & Goett, R. R. (2019). Audiovisual recording in the emergency department: Ethical and legal issues. *Am J Emerg Med, 37*(12), 2248-2252. doi:10.1016/j.ajem.2019.158408

Jacobs, B., Duncan, J. R., Street, M., & Murray, D. (2010). Audio and video recording system for routine documentation of fluoroscopic procedures. *J Vasc Interv Radiol, 21*(5), 725-729. doi:10.1016/j.jvir.2010.01.030

Jay, L. S., Comar, D., & Govenlock, L. D. (1999). A video study of Australian domestic food-handling practices. *J Food Prot, 62*(11), 1285-1296. doi:https://doi.org/10.4315/0362-028X-62.11.1285

Jeanes, A., Coen, P. G., Gould, D. J., & Drey, N. S. (2019). Validity of hand hygiene compliance measurement by observation: A systematic review. *Am J Infect Control, 47*(3), 313-322. doi:10.1016/j.ajic.2018.08.004

Jeanes, A., Coen, P. G., Wilson, A. P., Drey, N. S., & Gould, D. J. (2015). Collecting the data but missing the point: validity of hand hygiene audit data. *J Hosp Infect, 90*(2), 156-162. doi:10.1016/j.jhin.2015.02.018

Jones, S. (1992). Was there a Hawthorne Effect? *American Journal of Sociology, 98*(3), 451-468. doi:130.194.20.173

Kelly, J. W., Blackhurst, D., McAtee, W., & Steed, C. (2016). Electronic hand hygiene monitoring as a tool for reducing health care-associated methicillin-resistant Staphylococcus aureus infection. *Am J Infect Control, 44*(8), 956-957. doi:10.1016/j.ajic.2016.04.215

Kelly, J. W., Blackhurst, D., Steed, C., & Diller, T. (2015). A response to the article, "Comparison of Hand Hygiene Monitoring Using the My 5 Moments for Hand Hygiene Method Versus a Wash in-Wash out Method". *Am J Infect Control, 43*(8), 901-902. doi:10.1016/j.ajic.2015.02.032

Kingston, L., O'Connell, N. H., & Dunne, C. P. (2016). Hand hygiene-related clinical trials reported since 2010: a systematic review. *J Hosp Infect, 92*(4), 309-320. doi:10.1016/j.jhin.2015.11.012

Kinsella, G., Thomas, A. N., & Taylor, R. J. (2007). Electronic surveillance of wall-mounted soap and alcohol gel dispensers in an intensive care unit. *J Hosp Infect, 66*(1), 34-39. doi:10.1016/j.jhin.2007.02.018

Knighton, S. C., & Davis, J. (2018). Journal Club: Quantifying the Hawthorne effect using overt and covert observation of hand hygiene at a tertiary care hospital in Saudi Arabia. *Am J Infect Control, 46*(8), 928-929. doi:10.1016/j.ajic.2018.04.212

Koff, M. D., Corwin, H. L., Beach, M. L., Surgenor, S. D., & Loftus, R. W. (2011). Reduction in ventilator associated pneumonia in a mixed intensive care unit after initiation of a novel hand hygiene program. *J Crit Care, 26*(5), 489-495. doi:10.1016/j.jcrc.2010.12.013

Koff, M. D., Loftus, R. W., Burchman, C. C., Schwartzman, J. D., Read, M. E., Henry, E. S., & Beach, M. L. (2009). Reduction in intraoperative bacterial contamination of peripheral intravenous tubing through the use of a novel device. *Anesthesiology, 110*(5), 978-985. doi:10.1097/ALN.0b013e3181a06ec3

Kogan, J. R., Conforti, L., Bernabeo, E., Iobst, W., & Holmboe, E. (2011). Opening the black box of clinical skills assessment via observation: a conceptual model. *Med Educ, 45*(10), 1048-1060. doi:10.1111/j.1365-2923.2011.04025.x

Kohli, E., Ptak, J., Smith, R., Taylor, E., Talbot, E. A., & Kirkland, K. B. (2009). Variability in the Hawthorne effect with regard to hand hygiene performance in high- and low-performing inpatient care units. *Infect Control Hosp Epidemiol, 30*(3), 222-225. doi:10.1086/595692

Korhonen, A., Ojanpera, H., Puhto, T., Jarvinen, R., Kejonen, P., & Holopainen, A. (2015). Adherence to hand hygiene guidelines - significance of measuring fidelity. *J Clin Nurs, 24*(21-22), 3197-3205. doi:10.1111/jocn.12969

Kruger, J. D., D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77*(6), 1121-1134.

Kwok, Y. L. A., Harris, P., & McLaws, M.-L. (2017). Social cohesion: the missing factor required for a sucessful hand hygiene program. *American Journal of Infection Control, 45*(3), 222-227. doi:10.1016/a.ajic.10.021

Kwok, Y. L. A., Juergens, C. P., & McLaws, M.-L. (2016). Automated hand hygiene auditing with and without an intervention. *American Journal of Infection Control, 44*(2016), 1475-1480. doi:10.1016/j.JIC.2016.08.014

Labarraque, A. G. (1831). Instructions and Observations concerning the use of the Chlorides of Soda and Lime. *The American Journal of the Medical Sciences, 8*(15), 207-210.

Lacey, G., Morrow, H., Ruttle, J., Green, S., Cronin, S., & Cullen, V. (2019). SUREWASH. Retrieved from https://surewash.com/about/#surewash

Larson, E. L. (2013). Monitoring hand hygiene: meaningless, harmful, or helpful? *Am J Infect Control, 41*(5 Suppl), S42-45. doi:10.1016/j.ajic.2012.09.029

Larson, E. L., Early, E., Cloonan, P., Sugrue, S., & Parides, M. (2000). An organizational climate intervention associated with increased handwashing and decreased nosocomial infections. *Behav Med, 26*(1), 14-22. doi:10.1080/08964280009595749

Larson, E. L., & Kretzer, E. K. (1995). Compliance with handwashing and barrier precautions. *J Hosp Infect, 30 Suppl*, 88-106. doi:10.1016/0195-6701(95)90010-1

Latvala, E., Vuokila-Oikkonen, P., & Janhonen, S. (2000). Videotaped recording as a method of participant observation in psychiatric nursing research. *Journal of Advanced Nursing, 31*(5), 1252-1257. doi:10.1046/j.1365-2648.2000.01383.x

Le Bris, A., Mazille-Orfanos, N., Simonot, P., Luherne, M., Flamant, C., Gascoin, G., . . . Pladys, P. (2020). Parents' and healthcare professionals' perceptions of the use of live video recording in neonatal units: a focus group study. *BMC Pediatr, 20*(1), 143. doi:10.1186/s12887-020-02041-9

Lebovic, G., Siddiqui, N., & Muller, M. P. (2013). Predictors of hand hygiene compliance in the era of alcohol-based hand rinse. *J Hosp Infect, 83*(4), 276-283. doi:10.1016/j.jhin.2013.01.001

Levchenko, A. I., Boscart, V. M., & Fernie, G. R. (2011). The feasibility of an automated monitoring system to improve nurses' hand hygiene. *Int J Med Inform, 80*(8), 596-603. doi:10.1016/j.ijmedinf.2011.04.002

Levchenko, A. I., Boscart, V. M., & Fernie, G. R. (2013). The effect of automated monitoring and real-time prompting on nurses' hand hygiene performance. *Comput Inform Nurs, 31*(10), 498-504. doi:10.1097/01.NCN.0000432124.53902.1d

Levchenko, A. I., Boscart, V. M., & Fernie, G. R. (2014). Automated monitoring: a potential solution for achieving sustainable improvement in hand hygiene practices. *Comput Inform Nurs, 32*(8), 397-403. doi:10.1097/CIN.0000000000000067

Lindon-Morris, E., & Laidlaw, A. (2014). Anxiety and self-awareness in video feedback. *Clin Teach, 11*(3), 174-178. doi:10.1111/tct.12103

Mackrill, J., Dawson, C., Garvey, B., & Gould, D. (2017). Exploring new approaches to improve hand hygiene monitoring in healthcare. *Infection, Disease & Health, 22*(1), 21-27. doi:10.1016/j.idh.2016.12.004

Mahida, N. (2016). Hand hygiene compliance: are we kidding ourselves? *J Hosp Infect, 92*(4), 307-308. doi:10.1016/j.jhin.2016.02.004

Makary, M. A. (2013). The power of video recording: taking quality to the next level. *JAMA, 309*(15), 1591-1592. doi:10.1001/jama.2013.595

Manoukian, S., Stewart, S., Graves, N., Mason, H., Robertson, C., Kennedy, S., . . . Reilly, J. (2021). Evaluating the post-discharge cost of healthcare-associated infection in NHS Scotland. *J Hosp Infect, 114*, 51-58. doi:10.1016/j.jhin.2020.12.026

Marra, A. R., & Edmond, M. B. (2014). New technologies to monitor healthcare worker hand hygiene. *Clin Microbiol Infect, 20*(1), 29-33. doi:10.1111/1469-0691.12458

Marra, A. R., Moura, D. F., Jr., Paes, A. T., dos Santos, O. F., & Edmond, M. B. (2010). Measuring rates of hand hygiene adherence in the intensive care setting: a comparative study of direct observation, product usage, and electronic counting devices. *Infect Control Hosp Epidemiol, 31*(8), 796-801. doi:10.1086/653999

Martin-Madrazo, C., Canada-Dorado, A., Salinero-Fort, M. A., Abanades-Herranz, J. C., Arnal-Selfa, R., Garcia-Ferradal, I., . . . Soto-Diaz, S. (2009). Effectiveness of a training programme to improve hand hygiene compliance in primary healthcare. *BMC Public Health, 9*, 469. doi:10.1186/1471-2458-9-469

Masroor, N., Doll, M., Stevens, M., & Bearman, G. (2017). Approaches to hand hygiene monitoring: From low to high technology approaches. *Int J Infect Dis, 65*, 101-104. doi:10.1016/j.ijid.2017.09.031

McDonald, E. G., Smyth, E., Smyth, L., & Lee, T. C. (2018). Hand hygiene "hall monitors": Leveraging the Hawthorne effect. *Am J Infect Control, 46*(6), 706-707. doi:10.1016/j.ajic.2017.11.030

McGurkin, M., & Govednik, J. (2015). A Review of Electronic Hand Hygiene Monitoring: Considerations for Hospital Management in Data Collection, Healthcare Worker Supervision, and Patient Perception. *Journal of Healthcare Management, 60*(5), 348-361.

McLaws, M. L., & Kwok, Y. L. A. (2018). Hand hygiene compliance rates: Fact or fiction? *Am J Infect Control*. doi:10.1016/j.ajic.2018.03.030

McLennan, S., Rich, L. E., & Truog, R. D. (2015). Apologies in medicine: legal protection is not enough. *CMAJ, 187*(5), E156-159. doi:10.1503/cmaj.131860

Mir, M. A., Evans, R. W., Marshall, R. J., Newcombe, R. G., & Hayes, T. M. (1989). The use of videorecordings of medical postgraduates in improving clinical skills. *Medical Education, 23*, 276-281.

Mitchell, B. G., Shaban, R. Z., MacBeth, D., Wood, C.-J., & Russo, P. L. (2017). The burden of healthcare-associated infection in Australian hospitals: A systematic review of the literature. *Infection, Disease & Health, 22*(3), 117-128. doi:10.1016/j.idh.2017.07.001

Moller-Sorensen, H., Korshin, A., Morgensen, T., & Hoiby, N. (2016). New technology markedly oimproves hand-hygiene performance among healthcare workers after restroom visits. *Journal of Hospital Infection, 92*(2016), 337-339. doi:10.1016/j.jhijn.2015.09.012

Momen, K., & Fernie, G. R. (2010). Nursing activity recognition using an inexpensive game controller: An application to infection control. *Technol Health Care, 18*(6), 393-408. doi:10.3233/THC-2010-0600

Monsalve, M. N., Pemmaraju, S. V., Thomas, G. W., Herman, T., Segre, A. M., & Polgreen, P. M. (2014). Do peer effects improve hand hygiene adherence among healthcare workers? *Infect Control Hosp Epidemiol, 35*(10), 1277-1285. doi:10.1086/678068

Morgan, D. J., Pineles, L., Shardell, M., Young, A., Ellingson, K., Jernigan, J. A., . . . Perencevich, E. N. (2012). Automated hand hygiene count devices may better measure compliance than human observation. *Am J Infect Control, 40*(10), 955-959. doi:10.1016/j.ajic.2012.01.026

Morse, J. M. (2015). Critical Analysis of Strategies for Determining Rigor in Qualitative Inquiry. *Qual Health Res, 25*(9), 1212-1222. doi:10.1177/1049732315588501

Mortimer, E., A., Lipsitz, P., J., Wolinsky, E., Gonzaga, A., J. , & Rammelkamp, C., H. (1962). Transmission of Staphylococci Between Newborns: Importance of the Hands of Personnel. *The American Journal of Diseases of CHildren, 104*(3), 289-295. doi:doi:10.1001/archpedi.1962.02080030291012

Muller, M. P., Levchenko, A. I., Ing, S., Pong, S. M., & Fernie, G. R. (2014). Electronic monitoring of individual healthcare workers' hand hygiene event rate. *Infect Control Hosp Epidemiol, 35*(9), 1189-1192. doi:10.1086/677631

Nguyen-Duc, T., Chan1, P.Y., Tay, A., Chen, A., Nguyen, J.T., Lyall, J., De Freitas, M. (2022). Estimation of Clinical Workload and Patient Activity using Deep Learning and Optical Flow. doi:https://doi.org/10.48550/arXiv.2202.04748

NHHI. (2022). National Hand Hygiene Initiative. Retrieved from https://nhhi.safetyandquality.gov.au/en_AU/NHHI/dashboard

NHMRC. (2014). *Ethical Considerations in Quality Assurance and Evaluation Activities*. Canberra: Commonwealth of Australia Retrieved from https://www.nhmrc.gov.au/about-us/resources/ethical-considerations-quality-assurance-and-evaluation-activities.

Nilsen, S., & Baerheim, A. (2005). Feedback on video recorded consultations in medical teaching: why students loathe and love it - a focus-group based qualitative study. *BMC Med Educ, 5*, 28. doi:10.1186/1472-6920-5-28

Nishimura, S., Kagehira, M., Kono, F., Nishimura, M., & Taenaka, N. (1999). Handwahing before entering the intensive care unit: What we learned from continuous video-camera surveillance. *American Journal of Infection Control, 27*(4), 367-369.

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis. *International Journal of Qualitative Methods, 16*(1). doi:10.1177/1609406917733847

O'Donnell, C. P., Kamlin, C. O., Davis, P. G., & Morley, C. J. (2008). Ethical and legal aspects of video recording neonatal resuscitation. *Arch Dis Child Fetal Neonatal Ed, 93*(2), F82-84. doi:10.1136/adc.2007.118505

Oakley, E., Stocker, S., Staubli, G., & Young, S. (2006). Using video recording to identify management errors in pediatric trauma resuscitation. *Pediatrics, 117*(3), 658-664. doi:10.1542/peds.2004-1803

Orwell, G. (2008). *Nineteen Eighty-four*: Penguin Books Ltd, London, UK.

Overdyk, F. J., Dowling, O., Newman, S., Glatt, D., Chester, M., Armellino, D., . . . DiCapua, J. F. (2016). Remote video auditing with real-time feedback in an academic surgical suite improves safety and efficiency metrics: a cluster randomised study. *BMJ Qual Saf, 25*(12), 947-953. doi:10.1136/bmjqs-2015-004226

Palmore, T. N., & Henderson, D. K. (2012). Big brother is washing...Video surveillance for hand hygiene adherence, through the lenses of efficacy and privacy. *Clin Infect Dis, 54*(1), 8-9. doi:10.1093/cid/cir781

Pan, S. C., Tien, K. L., Hung, I. C., Lin, Y. J., Sheng, W. H., Wang, M. J., . . . Chen, Y. C. (2013). Compliance of health care workers with hand hygiene practices: independent advantages of overt and covert observers. *PLoS One, 8*(1), e53746. doi:10.1371/journal.pone.0053746

Parker, H., Farrell, O., Bethune, R., Hodgetts, A., & Mattick, K. (2019). Pharmacist-led, video-stimulated feedback to reduce prescribing errors in doctors-in-training: A mixed methods evaluation. *Br J Clin Pharmacol, 85*(10), 2405-2413. doi:10.1111/bcp.14065

Parliament of South Australia. (2016). *Surveillance Devices Act*. South Australia.

Parliament of Victoria. (2019). *Surveillance Devices Act*. Victoria: Parliment of Victoria Retrieved from https://content.legislation.vic.gov.au/sites/default/files/4a03fae7-bea1-3082-adea-acaa473530a4_99-21aa040%20authorised.pdf.

Parry, R., Pino, M., Faull, C., & Feathers, L. (2016). Acceptability and design of video-based research on healthcare communication: Evidence and recommendations. *Patient Educ Couns, 99*(8), 1271-1284. doi:10.1016/j.pec.2016.03.013

Parsons, H. M. (1974). What happened at Hawthorne? *Sciene, 183*(4128), 922-932.

Pedersen, A., Getty Ritter, E., Beaton, M., & Gibbons, D. (2017). Remote Video Auditing in the Surgical Setting. *AORN J, 105*(2), 159-169. doi:10.1016/j.aorn.2016.11.019

Peltier, L. F. (1969). Television videotape recordings for teaching emergency medical care. *The Journal of Trauma: Injury, Infection and Critical Care, 9*(9), 823. doi:https://doi.org/10.5555/uri:pii:0039606069902475

Peltier, L. F., Geertsma, R. H., & Youmans, R. L. (1969). Television Videotape Recording: An adjunct in teaching emergency medical care. *Surgery, 66*(1), 233-236.

Pickering, A. J., Blum, A. G., Breiman, R. F., Ram, P. K., & Davis, J. (2014). Video surveillance captures student hand hygiene behavior, reactivity to observation, and peer influence in Kenyan primary schools. *PLoS One, 9*(3), e92571. doi:10.1371/journal.pone.0092571

Pincock, T., Bernstein, P., Warthman, S., & Holst, E. (2012). Bundling hand hygiene interventions and measurement to decrease health care-associated infections. *Am J Infect Control, 40*(4 Suppl 1), S18-27. doi:10.1016/j.ajic.2012.02.008

Pineles, L. L., Morgan, D. J., Limper, H. M., Weber, S. G., Thom, K. A., Perencevich, E. N., . . . Landon, E. (2014). Accuracy of a radiofrequency identification (RFID) badge system to monitor hand hygiene behavior during routine clinical activities. *Am J Infect Control, 42*(2), 144-147. doi:10.1016/j.ajic.2013.07.014

Pires, D., & Pittet, D. (2017). Hand hygiene electronic monitoring: Are we there yet? *Am J Infect Control, 45*(5), 464-465. doi:10.1016/j.ajic.2016.12.019

Pittet, D. (2001). Improving adherence to hand hygiene practice: a multidisciplinary approach. *Emerg Infect Dis, 7*(2), 234-240. doi:10.3201/eid0702.700234

Pittet, D. (2002). Promotion of Hand Hygiene: Magic, Hype, or Scientific Challenge? *Infection Control and Hospital Epidemiology, 23*(2), 118-119. doi:DOI: 10.1086/502019

Pittet, D., Allegranzi, B., & Boyce, J. M. (2009). The World Health Organization Guidelines on Hand Hygiene in Health Care and their consensus recommendations. *Infect Control Hosp Epidemiol, 30*(7), 611-622. doi:10.1086/600379

Pittet, D., Allegranzi, B., Sax, H., Dharan, S., Pessoa-Silva, C. L., Donaldson, L., . . . Who Global Patient Safety Challenge, W. A. f. P. S. (2006). Evidence-based model for hand transmission during patient care and the role of improved practices. *Lancet Infect Dis, 6*(10), 641-652. doi:10.1016/S1473-3099(06)70600-4

Pittet, D., & Boyce, J. M. (2001). Hand hygiene and patient care: pursuing the Semmelweis legacy. *The Lancet Infectious Diseases, 1*(Supplement 1), 9-20. doi:10.1016/s1473-3099(09)70295-6

Pittet, D., Hugonnet, S., Harbarth, S., Mourouga, P., Sauvan, V., Touveneau, S., & Perneger, T. V. (2000). Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. *Lancet, 356*(9238), 1307-1312. doi:https://doi.org/10.1016/S0140-6736(00)02814-2

Polit, D. F., & Beck, C. T. (2008). *Nursing Research: Generating and Assessing Evidence for Nursing Practice* (8th ed.): Lippincott Williams & Wilkins.

Polit, D. F., & Hungler, B. P. (1999). *Nursing Research: Principles and Methods* (6 ed.): Lippincott Williams & Wilkins.

Pong, S., Holliday, P., & Fernie, G. (2018). Secondary measures of hand hygiene performance in health care available with continuous electronic monitoring of individuals. *Am J Infect Control*. doi:10.1016/j.ajic.2018.07.004

Raghavendra, M., & Rex, D. K. (2010). Patient interest in video recording of colonoscopy: a survey. *World J Gastroenterol, 16*(4), 458-461. doi:10.3748/wjg.v16.i4.458

Renkema, E., Broekhuis, M., & Ahaus, K. (2014). Conditions that influence the impact of malpractice litigation risk on physicians' behavior regarding patient safety. *BMC Health Serv Res, 14*, 38. doi:10.1186/1472-6963-14-38

Rex, D. K., Hewett, D. G., Raghavendra, M., & Chalasani, N. (2010). The impact of videorecording on the quality of colonoscopy performance: a pilot study. *Am J Gastroenterol, 105*(11), 2312-2317. doi:10.1038/ajg.2010.245

Rosenthal, V. D., Guzman, S., & Safdar, N. (2005). Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. *Am J Infect Control, 33*(7), 392-397. doi:10.1016/j.ajic.2004.08.009

Ryan, J. (1991). Observing and Normalizing: Foucault, Discipline, and Inequality in Schooling: BIG BROTHER IS WATCHING YOU. *The Journal of Educational Thought (JET) / Revue de la Pensée Éducative, 25*(2), 104-119.

Sahud, A. G., Bhanot, N., Narasimhan, S., & Malka, E. S. (2012). Feasibility and effectiveness of an electronic hand hygiene feedback device targeted to improve rates of hand hygiene. *J Hosp Infect, 82*(4), 271-273. doi:10.1016/j.jhin.2012.09.006

Sahud, A. G., Bhanot, N., Radhakrishnan, A., Bajwa, R., Manyam, H., & Post, J. C. (2010). An electronic hand hygiene surveillance device: a pilot study exploring surrogate markers for hand hygiene compliance. *Infect Control Hosp Epidemiol, 31*(6), 634-639. doi:10.1086/652527

Sanchez-Carrillo, L. A., Rodriguez-Lopez, J. M., Galarza-Delgado, D. A., Baena-Trejo, L., Padilla-Orozco, M., Mendoza-Flores, L., & Camacho-Ortiz, A. (2016). Enhancement of hand hygiene compliance among health care workers from a hemodialysis unit using video-monitoring feedback. *Am J Infect Control, 44*(8), 868-872. doi:10.1016/j.ajic.2016.01.040

Sandelowski, M. (1995). Qualitative analysis: what it is and how to begin. *Res Nurs Health, 18*(4), 371-375. doi:10.1002/nur.4770180411

Sax, H., Allegranzi, B., Chraiti, M. N., Boyce, J., Larson, E., & Pittet, D. (2009a). The World Health Organization hand hygiene observation method. *Am J Infect Control, 37*(10), 827-834. doi:10.1016/j.ajic.2009.07.003

Sax, H., Allegranzi, B., Chraiti, M. N., Boyce, J. M., Larson, E. L., & Pittet, D. (2009b). The World Health Organization hand hygiene observation method. *Am J Infect Control, 37*(10), 827-834. doi:10.1016/j.ajic.2009.07.003

Sax, H., Allegranzi, B., Uckay, I., Larson, E. L., Boyce, J. M., & Pittet, D. (2007). 'My five moments for hand hygiene': a user-centred design approach to understand, train, monitor and report hand hygiene. *J Hosp Infect, 67*(1), 9-21. doi:10.1016/j.jhin.2007.06.004

Scheithauer, S., Bickenbach, J., Heisel, H., Fehling, P., Marx, G., & Lemmen, S. (2018). Do WiFi-based hand hygiene dispenser systems increase hand hygiene compliance? *Am J Infect Control, 46*(10), 1192-1194. doi:10.1016/j.ajic.2018.03.026

Scheithauer, S., Haefner, H., & Schwanz, T. (2009). Compliance with hand hygiene on surgical, medical, and neurologic intensive care units: Direct observation versus calculated disinfectant usage. *American Journal of Infection Control, 37*(10), 835-841. doi:10.1016/j.ajic.2009.06.005

Scott, M., Watermeyer, J., & Wessels, T. M. (2020). Video-recording complex health interactions in a diverse setting: Ethical dilemmas, reflections and recommendations. *Dev World Bioeth, 20*(1), 16-26. doi:10.1111/dewb.12226

Semmelweis, I. (2008). The Etiology, Concept, and Prophylaxis of Childbed Fever (excerpts). *Social Medicine, 3*(1), 4-12.

Sendelbach, S., & Funk, M. (2013). Alarm fatigue: a patient safety concern. *AACN Adv Crit Care, 24*(4), 378-386; quiz 387-378. doi:10.1097/NCI.0b013e3182a903f9

Shah, R., Patel, D. V., Shah, K., Phatak, A., & Nimbalkar, S. (2015). Video Surveillance Audit of Hand-washing Practices in a Neonatal Intensive Care Unit. *Indian Pediatr, 52*(5), 409-411.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*(2), 63-75. doi:10.3233/efi-2004-22201

Smiddy, M. P., Murphy, O. M., Savage, E., Fitzgerald, A. P., O' Sullivan, B., Murphy, C., . . . Browne, J. P. (2019). Efficacy of observational hand hygiene audit with targeted feedback on doctors' hand hygiene compliance: A retrospective time series analysis. *Journal of Infection Prevention*. doi:10.1177/1757177419833165

Sodre da Costa, L. S., Neves, V. M., Marra, A. R., Sampaio Camargo, T. Z., Fatima dos Santos Cardoso, M., da Silva Victor, E., . . . Edmond, M. B. (2013). Measuring hand hygiene compliance in a hematology-oncology unit: a comparative study of methodologies. *Am J Infect Control, 41*(11), 997-1000. doi:10.1016/j.ajic.2013.03.301

Srigley, J. A., Furness, C. D., Baker, G. R., & Gardam, M. (2014). Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. *BMJ Qual Saf, 23*(12), 974-980. doi:10.1136/bmjqs-2014-003080

Srigley, J. A., Gardam, M., Fernie, G., Lightfoot, D., Lebovic, G., & Muller, M. P. (2015). Hand hygiene monitoring technology: a systematic review of efficacy. *J Hosp Infect, 89*(1), 51-60. doi:10.1016/j.jhin.2014.10.005

Srigley, J. A., Lightfoot, D., Fernie, G., Gardam, M., & Muller, M. P. (2013). Hand hygiene monitoring technology: protocol for a systematic review. *Syst Rev, 2*(101), 101. doi:10.1186/2046-4053-2-101

Stackelroth, J., & Shaban, R. Z. (2011). The challenges of implementing a national hand hygiene initiative in rural and remote areas: Is it time for a new approach to auditing? *Healthcare infection, 16*(2), 63-70. doi:10.1071/hi11001

Stackelroth, J., Sinnott, M., & Shaban, R. Z. (2015). Hesitation and error: Does product placement in an emergency department influence hand hygiene performance? *Am J Infect Control, 43*(9), 913-916. doi:10.1016/j.ajic.2015.04.199

Steed, C., Kelly, J. W., Blackhurst, D., Boeker, S., Diller, T., Alper, P., & Larson, E. (2011). Hospital hand hygiene opportunities: where and when (HOW2)? The HOW2 Benchmark Study. *Am J Infect Control, 39*(1), 19-26. doi:10.1016/j.ajic.2010.10.007

Stewardson, A., & Pittet, D. (2011). Quicker, easier, and cheaper? The promise of automated hand hygiene monitoring. *Infect Control Hosp Epidemiol, 32*(10), 1029-1031. doi:10.1086/662023

Stewardson, A. J., Sax, H., Gayet-Ageron, A., Touveneau, S., Longtin, Y., Zingg, W., & Pittet, D. (2016). Enhanced performance feedback and patient participation to improve hand hygiene compliance of health-care workers in the setting of established multimodal promotion: a single-centre, cluster randomised controlled trial. *The Lancet Infectious Diseases, 16*(12), 1345-1355. doi:10.1016/s1473-3099(16)30256-0

Stewardson, A. J., Sax, H., Longet-Di Pietro, S., & Pittet, D. (2011). Impact of observation and analysis methodology when reporting hand hygiene data. *J Hosp Infect, 77*(4), 358-359. doi:10.1016/j.jhin.2010.12.008

Stewart, S., Robertson, C., Kennedy, S., Kavanagh, K., Haahr, L., Manoukian, S., . . . Reilly, J. (2021). Personalized infection prevention and control: identifying patients at risk of healthcare-associated infection. *J Hosp Infect, 114*, 32-42. doi:10.1016/j.jhin.2021.03.032

Stone, P. W. (2009). Economic burden of healthcare-associated infections: an American perspective. *Expert Rev Pharmacoecon Outcomes Res, 9*(5), 417-422. doi:10.1586/erp.09.53

Storey, S. J., FitzGerald, G., Moore, G., Knights, E., Atkinson, S., Smith, S., . . . Wilson, A. P. (2014). Effect of a contact monitoring system with immediate visual feedback on hand hygiene compliance. *J Hosp Infect, 88*(2), 84-88. doi:10.1016/j.jhin.2014.06.014

Suetens, C., Hopkins, S., Kolman, J., & Hogberg, L. D. (2013). *European Centre for Disease Prevention and Control: Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals*. Retrieved from Stockholm: https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/healthcare-associated-infections-antimicrobial-use-PPS.pdf

Sunkesula, V. C., Kundrapu, S., & Donskey, C. J. (2015). Response to the Letter to the Editor regarding Comparison of hand hygiene monitoring using the My 5 Moments for Hand Hygiene method versus the Wash In-Wash Out method. *Am J Infect Control, 43*(8), 902. doi:10.1016/j.ajic.2015.04.205

Swoboda, S. M., Earsing, K., Strauss, K., Lane, S., & Lipsett, P. A. (2004). Electronic monitoring and voice prompts improve hand hygiene and decrease nosocomial infections in an intermediate care unit. *Crit Care Med, 32*(2), 358-363. doi:10.1097/01.CCM.0000108866.48795.0F

Swoboda, S. M., Earsing, K., Strauss, K., Lane, S., & Lipsett, P. A. (2007). Isolation status and voice prompts improve hand hygiene. *Am J Infect Control, 35*(7), 470-476. doi:10.1016/j.ajic.2006.09.009

Talbot, T. R., Johnson, J. G., Fergus, C., Domenico, J. H., Schaffner, W., Daniels, T. L., . . . Hickson, G. B. (2013). Sustained improvement in hand hygiene adherence: utilizing shared accountability and financial incentives. *Infect Control Hosp Epidemiol, 34*(11), 1129-1136. doi:10.1086/673445

Umscheid, C. A., Mitchell, M. D., Doshi, J. A., Agarwal, R., Williams, K., & Brennan, P. J. (2011). Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. *Infect Control Hosp Epidemiol, 32*(2), 101-114. doi:10.1086/657912

Vaidotas, M., Yokota, P. K., Marra, A. R., Camargo, T. Z., Victor Eda, S., Gysi, D. M., . . . Edmond, M. B. (2015). Measuring hand hygiene compliance rates at hospital entrances. *Am J Infect Control, 43*(7), 694-696. doi:10.1016/j.ajic.2015.03.008

van Dalen, A., Legemaate, J., Schlack, W. S., Legemate, D. A., & Schijven, M. P. (2019). Legal perspectives on black box recording devices in the operating environment. *Br J Surg, 106*(11), 1433-1441. doi:10.1002/bjs.11198

van de Mortel, T., & Murgo, M. (2006). An examination of covert observation and solution audit as tools to measure the success of hand hygiene interventions. *Am J Infect Control, 34*(3), 95-99. doi:10.1016/j.ajic.2005.07.006

Venkatesh, A. K., Lankford, M. G., Rooney, D. M., Blachford, T., Watts, C. M., & Noskin, G. A. (2008). Use of electronic alerts to enhance hand hygiene compliance and decrease transmission of vancomycin-resistant Enterococcus in a hematology unit. *Am J Infect Control, 36*(3), 199-205. doi:10.1016/j.ajic.2007.11.005

VICNISS. (2017). VICNISS SURVEILLANCE MODULE: Surgical Site Infection (SSI) Protocol. In.

Walton, M., Harrison, R., Smith-Merry, J., Kelly, P., Manias, E., Jorm, C., & Iedema, R. (2019). Disclosure of adverse events: a data linkage study reporting patient experiences among Australian adults aged >/=45 years. *Aust Health Rev, 43*(3), 268-275. doi:10.1071/AH17179

Wang, C., Jiang, W., Yang, K., Yu, D., Newn, J., Sarsenbayeva, Z., . . . Kostakos, V. (2021). Electronic Monitoring Systems for Hand Hygiene: Systematic Review of Technology. *J Med Internet Res, 23*(11), e27880. doi:10.2196/27880

Ward, M. A., Schweizer, M. L., Polgreen, P. M., Gupta, K., Reisinger, H. S., & Perencevich, E. N. (2014). Automated and electronically assisted hand hygiene monitoring systems: a systematic review. *Am J Infect Control, 42*(5), 472-478. doi:10.1016/j.ajic.2014.01.002

Weinger, M. B. (2002). Human Factors Research in Anesthesia Patient Safety: Techniques to Elucidate Factors Affecting Clinical Task Performance and Decision Making. *Journal of the American Medical Informatics Association, 9*(90061), 58S-63. doi:10.1197/jamia.M1229

Weinger, M. B., Gonzales, D. C., Slagle, J., & Syeed, M. (2004a). Video capture of clinical care to enhance patient safety. *Qual Saf Health Care, 13*(2), 136-144. doi:http://dx.doi.org/10.1136/qshc.2002.4143

Weinger, M. B., Gonzales, D. C., Slagle, J., & Syeed, M. (2004b). Video capture of clinical care to enhance patient safety. *Quality and Safety in Health Care, 13*(2), 136-144. doi:10.1136/qshc.2002.4143

Welsh, S., Hassiotis, A., O'Mahoney, G., & Deahl, M. (2003). Big brother is watching you--the ethical implications of electronic surveillance measures in the elderly with dementia and in adults with learning difficulties. *Aging Ment Health, 7*(5), 372-375. doi:10.1080/1360786031000150658

WHO. (2002). *Prevention of hospital-acquired infections: A practical guide*. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/67350/WHO_CDS_CSR_EPH_2002.12.pdf?sequence=1&isAllowed=y

WHO. (2009). *WHO Guidelines on Hand Hygiene in Healthcare*. Retrieved from Geneva, Switzerland: http://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906_eng.pdf?sequence=1

WHO. (2011). *Report on the Burden of Endemic Health Care-Associated Infection Worldwide: A systematic review of the literature* (B. Allegranzi Ed.). Geneva, Switzerland: WHO Document Production Services.

WHO. (2013). Systematic literature review of automated/electronic systems for hand hygiene monitoring: Preliminary results. Retrieved from http://www.who.int/gpsc/5may/automated-hand-hygiene-monitoring.pdf

WHO. (2016). *Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level*. Geneva, Switzerland: WHO Document Production Services.

Wiemken, T. L., Furmanek, S. P., Mattingly, W. A., Haas, J., Ramirez, J. A., & Carrico, R. M. (2018). Googling your hand hygiene data: Using Google Forms, Google Sheets, and R to collect and automate analysis of hand hygiene compliance monitoring. *Am J Infect Control, 46*(6), 617-619. doi:10.1016/j.ajic.2018.01.010

Williams, R. G., Klamen, D. A., & McGaghie, W. C. (2003). Cognitive, social and environmental sources of bias in clinical performance ratings. *Teach Learn Med, 15*(4), 270-292. doi:10.1207/S15328015TLM1504_11

Woolrych, R., Zecevic, A., Sixsmith, A., Sims-Gould, J., Feldman, F., Chaudhury, H., . . . Robinovitch, S. N. (2015). Using video capture to investigate the causes of falls in long-term care. *Gerontologist, 55*(3), 483-494. doi:10.1093/geront/gnu053

Wu, A. W., McCay, L., Levinson, W., Iedema, R., Wallace, G., Boyle, D. J., . . . Gallagher, T. H. (2017). Disclosing Adverse Events to Patients: International Norms and Trends. *J Patient Saf, 13*(1), 43-49. doi:10.1097/PTS.0000000000000107

Wyer, M., Jackson, D., Iedema, R., Hor, S. Y., Gilbert, G. L., Jorm, C., . . . Carroll, K. (2015). Involving patients in understanding hospital infection control using visual methods. *J Clin Nurs, 24*(11-12), 1718-1729. doi:10.1111/jocn.12779

Xi, H., Cao, J., Liu, J., Li, Z., Kong, X., Wang, Y., . . . Zhang, L. (2016). Improving health care workers' protection against infection of Ebola hemorrhagic fever through video surveillance. *Am J Infect Control, 44*(8), 922-924. doi:10.1016/j.ajic.2016.02.015

Xiao, Y., Seagull, F. J., Bochicchio, G. V., Guzzo, J. L., Dutton, R. P., Sisley, A., . . . Scalea, T. M. (2007). Video-based training increases sterile-technique compliance during central venous catheter insertion. *Crit Care Med, 35*(5), 1302-1306. doi:10.1097/01.CCM.0000263457.81998.27

Xu, Q., Liu, Y., Cepulis, D., Jerde, A., Sheppard, R. A., Tretter, K., . . . Huang, J. (2021). Implementing an electronic hand hygiene system improved compliance in the intensive care unit. *Am J Infect Control, 49*(12), 1535-1542. doi:10.1016/j.ajic.2021.05.014

Yeates, P., O'Neill, P., Mann, K., & Eva, K. (2013). Seeing the same thing differently: mechanisms that contribute to assessor differences in directly-observed performance assessments. *Adv Health Sci Educ Theory Pract, 18*(3), 325-341. doi:10.1007/s10459-012-9372-1

Yin, J., Reisinger, H. S., Vander Weg, M., Schweizer, M. L., Jesson, A., Morgan, D. J., . . . Perencevich, E. N. (2014). Establishing evidence-based criteria for directly observed hand hygiene compliance monitoring programs: a prospective, multicenter cohort study. *Infect Control Hosp Epidemiol, 35*(9), 1163-1168. doi:10.1086/677629

Zhongna, Z., Xi, C., Yu-Chia, C., Zhihai, H., Han, T. X., & Keller, J. M. (2008). Activity Analysis, Summarization, and Visualization for Indoor Human Activity Monitoring. *IEEE Transactions on Circuits and Systems for Video Technology, 18*(11), 1489-1498. doi:10.1109/tcsvt.2008.2005612

APPENDICES

Appendix A: McKay, K.J., Shaban, R.Z., Ferguson, P. (2020). Hand hygiene compliance monitoring: Do video-based technologies offer opportunities for the future? Infection Disease and Health. 25(2), pp. 92-100. doi.org/10.1016/j.idh.2059.12.002.

Infection, Disease & Health (2020) 25, 92–100

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.journals.elsevier.com/infection-disease-and-health/

Discussion paper

Hand hygiene compliance monitoring: Do video-based technologies offer opportunities for the future?

Katherine J. Mckay [a,b,*], Ramon Z. Shaban [b,c,e], Patricia Ferguson [d,e]

[a] Infection Prevention and Control, Eastern Health, Box Hill, Victoria, Australia
[b] Susan Wakil School of Nursing and Midwifery & Marie Bashir Institute for Infectious Diseases and Biosecurity, Faculty of Medicine and Health, University of Sydney, NSW, Australia
[c] Nursing, Midwifery and Clinical Governance Directorate, Western Sydney Local Health District, Westmead, NSW, Australia
[d] School of Medicine & Marie Bashir Institute for Infectious Diseases and Biosecurity, Faculty of Medicine and Health, University of Sydney, NSW, Australia
[e] Westmead Hospital, Western Sydney Local Health District, Westmead, NSW, Australia

Received 1 August 2019; received in revised form 5 December 2019; accepted 9 December 2019
Available online 10 January 2020

KEYWORDS
Hand hygiene;
Compliance;
Healthcare-associated infection;
Direct observation;
Surveillance;
Audit

Abstract Hand hygiene is universally recognised as the primary measure to reduce healthcare-associated infections. Studies have convincingly demonstrated a link between increased hand hygiene compliance and reductions in rates of healthcare-associated infections. Direct observation is considered the gold standard method for monitoring hand hygiene compliance. Despite the acknowledged benefits of this approach, recent literature has highlighted a range of issues impacting on the reliability and validity of this data collection technique. The rise of technology in healthcare provides opportunity for alternative methods that promise advantages over direct human observation. There have been no published examples of systems that are able to capture data consistent with all the WHO '5 Moments for Hand Hygiene'. In this paper we explore current human-based auditing practises for monitoring hand hygiene compliance and raise for discussion and debate video-based technologies to monitor hand hygiene compliance. We raise questions regarding hybrid approaches that incorporate both direct human observation and indirect video-based surveillance, and the possible advantages and disadvantages therein for monitoring hand hygiene compliance. We suggest that such methods have the potential to ameliorate, or minimise, the inherent biases associated with direct observation, notably the Hawthorne Effect. Future research into the utility of a hybrid approach to auditing, including the technical specifications, efficacy, cost effectiveness and acceptability of such a model is warranted.

* Corresponding author. Infection Prevention and Control, Eastern Health, Box Hill, Victoria, Australia.
E-mail addresses: kmck4637@uni.sydney.edu.au (K.J. Mckay), ramon.shaban@sydney.edu.au (R.Z. Shaban), Patricia.Ferguson@health.nsw.gov.au (P. Ferguson).

https://doi.org/10.1016/j.idh.2019.12.002

to the problem of HAIs, it nonetheless is an essential component of overall infection prevention and control measures. It is widely considered to be "the single most important strategy in preventing healthcare-associated infection" [15]. Indeed, Palmore and Henderson [34] go so far as to label HCWs who do not practise appropriate hand hygiene as "offending healers who failed the patient" (p. 8). Talbot et al. [29]. Argues that hand hygiene compliance is a reflection or measure of the professionalism of healthcare workers and their practice.

Assessing hand hygiene performance and compliance: Direct observation

The WHO recommends that monitoring of hand hygiene compliance occurs using direct observation, which is also known as observational survey or human audit [18]. Direct observation is widely considered the gold standard data collection methodology and the WHO determines it to be the recommended compliance data collection technique internationally. In Australia, national regulatory standards require the collection of hand hygiene compliance rates under the auspices of the National Hand Hygiene Initiative [15,18,35,36]. The National Safety and Quality Health Service Standards (2nd Edition) detail the requirement that all accredited health services must have a hand hygiene program that is consistent with the current NHHI and jurisdictional requirements [37]. This entails the monitoring of hand hygiene compliance according to the WHO 5 Moments framework using the direct observation method as outlined by Hand Hygiene Australia (HHA) guidelines. Accordingly, hand hygiene auditors are required to complete specified training and annual revalidation in order to conduct hand hygiene compliance audits as part of the NHHI [15]. Direct observation, in this context, involves a trained auditor in the clinical setting observing HCW-patient interaction during care episodes and recording hand hygiene compliance or non-compliance according to the WHO 5 Moments for Hand Hygiene framework [15,38,39]. The compliance result is expressed as a percentage derived by dividing the number of correctly performed hand hygiene episodes by the number of hand hygiene opportunities, or in other words, the number of times that hand hygiene *should* have occurred [18]. The data collected is submitted three times per year via the online HHA portal. The data can be publicly accessed via the MyHospitals website (https://www.myhospitals.gov.au). The national compliance target is currently 80% for all health care worker groups and for all of the 5 Moments [15,37]. This figure is set by the Coalition of Australian Government Health Council, which comprises of all Australian states and territories. In some jurisdictions, achievement of this benchmark is linked to financial incentives [40].

Advantages and disadvantages of direct observation

Direct observation has many advantages. It enables compliance monitoring of all 5 Moments for Hand Hygiene [1,18,41–43]. It also allows identification of trends in compliance or non-compliance relating to specific moments, healthcare worker groups or clinical scenarios [18,41]. It permits the assessment of hand hygiene technique and the provision of on the spot, clinically contextual feedback and/or education to frontline staff, all of which can have a cueing, reminding or motivational effect on behaviour [1,18,43,44]. The physical presence of auditors reinforces the importance of hand hygiene and can prompt improved compliance through the Hawthorne Effect [18,42,44,45]. Finally, direct observation does not require expensive technology or infrastructure, meaning that it can potentially be used across a range of healthcare settings, regardless of their size, complexity or technological and/or infrastructure resources [18,46,47].

However, in recent times a range of issues and limitations have been identified with direct observation as the gold standard data collection method [48]. Some individuals have questioned whether compliance rates collected using this technique are reliable [42]. Direct observation has been described as an inherently flawed measure and one which has been challanged in the literature as the optimum data collection method [49]. Direct observation is also subject to various biases including the Hawthorne Effect where HCWs improve compliance as a consequence of the awareness of being observed. This effect is attributed to the "desire to please the official observer" [50]. Hence, this method may result in the reporting of behaviours and compliance rates which do not reflect the practice occurring when an observer is not present [22,39]. Various estimates have been made as to the inflating effect of the Hawthorne Effect and while it is considered likely to vary considerably, it has been estimated to potentially increase compliance by as high as threefold whilst the observer is present [36,39,41]. In addition, there are also concerns regarding the impacts of selection bias on the accuracy of direct observation as a data collection method. Selection bais is deemed to have occurred when auditors consciously or unconsciously preferentially audit certain HCWs or HCW groups or only at certain times of the day e.g. predominantly during weekday day shifts. This practice further reduces the reliability and generalisability of the results [42,46,49,51].

Although direct observation does not require expensive equipment or technology, the investment in human capital is significant. Auditors require training, annual re-validation and the time needed to actually collect the mandated observational data. Administrative oversite of the program is also required, and this is usually done by infection prevention and control practitioners [38,42,44,52,53]. Azim and McLaws [54] estimated that the annual cost of collecting the hand hygiene compliance data required by the NHHI was AUD $2.2 million or approximately $16,000 per hospital per audit period.

Criticisms are also made that the results represent only a very small proportion of the overall hand hygiene being performed and are impacted by being collected by multiple observers with poor or potentially poor inter-auditor reliability. Fries et al. [44]. estimates that only between 0.5 and 1.7% of all Moments occurring in each setting are recorded in a typical direct observation audit data collection. This low percentage is believed to further reduce the trustworthiness of the data due to the samples being

Highlights

- Hand hygiene is the primary measure to reduce healthcare-associated infections.
- Direct observation is considered the gold standard method for monitoring compliance.
- The reliability and validity of direct observation as a data collection method has been questioned, with inherent biases such as the Hawthorne Effect.
- Electronic Monitoring Systems offer possible solutions to, but also bring other challenges.
- Future research should explore the technical specifications, efficacy, cost effectiveness and acceptability of hybrid systems.

Healthcare-associated infections: A global threat to the quality and safety in healthcare

Healthcare-associated infections (HAIs) are adverse outcomes that lead to significant morbidity and mortality, increased financial burden for patients and health systems, and pain and suffering for patients and their families [1—3]. Accurate assessments of the incidence of HAI have proved to be a global challenge as noted in the 2011 World Health Organization (WHO) *Report on the Burden of Endemic Health Care- Associated Infection Worldwide* [4]. Stone [5] asserts that more than two million patients in the US are affected by HAIs every year and that more than 90,000 deaths are attributable to this cause. The European Centre for Disease Prevention and Control (ECDC) estimated 3.32 million cases in 2011—2012 [6]. In Australia the burden of HAI has been calculated to be approximately 165,000 cases per year, rendering them the most common complication for hospital patients [7,8]. Global estimates suggest that overall, 7% and 19% of patients in high and low income countries, respectively will experience a HAI as a consequence of healthcare treatment, with Allegranzi et al. [9]. describing HAIs as "one of the greatest challenges of modern medicine" (p. 9). HAIs are a significant burden on the economy, with annual costs in the US estimated to be between US $16.6 billion [10] and US $45 billion [5]. In Europe it is estimated to be €13—24 billion [11], while the cost may be as high as £1 billion for the National Health Service (NHS) in the UK [12].

Umscheild et al. [13]. suggest that while preventing all HAIs is not possible, between 55 and 70% are reasonably preventable which would equate to between 1.1 and 1.4 million avoidable infections and 49,500—63, 000 avoidable deaths annually in the US. The financial costs associated with these potentially preventable infections are estimated to be as high as $23 billion USD per annum. The ECDC suggests that a more conservative 20% of HAIs are preventable [14].

The first measure for HAI prevention and control: Hand hygiene

It is well-established that the hands of healthcare workers (HCW) are vectors for the transmission of the microorganisms that cause HAIs. Hand hygiene performed at the correct time and in the correct manner, using an appropriate soap or alcohol based hand rub (ABHR) product, will reduce the number of microorganisms on the hands and hence the risk of HAI [15—20]. The WHO '5 Moments for Hand Hygiene' was launched in 2005, and following further review and refinement, the *WHO Guidelines on Hand Hygiene in Healthcare* was formally launched in 2009 [21]. This framework provides specific guidance as to when HCWs should undertake hand hygiene to minimise the risk of transmission of microorganisms [15,18,22,23]. The WHO 'My 5 Moments' specify the performance of hand hygiene as follows: Moment 1 — before touching a patient; Moment 2 - before starting a clean/aseptic procedure; Moment 3 — after a body fluid exposure risk; Moment 4 — after touching a patient; and Moment 5 — after touching the patient surroundings [18]. While the WHO recommends the use of direct observation and the 5 Moment framework to monitor hand hygiene compliance [18], a review of the literature reveals that a number of different methodologies and compliance metrics are used worldwide [24]. For example, in Canada the '4 Moments Framework' is used to measure hand hygiene compliance [25]. Other countries report the use of proxy measures such as room entry/exit hand hygiene or wash in/wash out hand hygiene [26—28]. The justification for the latter approaches over the WHO '5 Moments' is that such data collection methods are simpler, more sustainable and less intrusive to gather [11,23,29,30].

Grayson and colleagues examined the effectiveness of Australia's National Hand Hygiene Initiative (NHHI) via a longitudinal study of the program for the eight years following its implementation in January 1, 2009. The study examined hospital participation, hand hygiene compliance reports (measured as the proportion of observed correct Moments), educational engagement, cost, and association with the incidence of healthcare-associated *Staphylococcus aureus* bacteraemia. They found that the significant sustained improvement in hand hygiene compliance was associated with a reduction in the incidence of healthcare-associated *S. aureus* bacteraemia [31]. This and a range of other studies have convincingly demonstrated that increased HCW hand hygiene compliance decreases HAI acquisition [32]. Kavanagh and Saman [33] argue that although hand hygiene does not present the total solution

statistically underpowered [36,44,51,53]. Daniels [38] argues that all of these factors result in inaccuracies and an over-estimation of hand hygiene compliance, as more covert methodologies have been reported to record significantly lower compliance rates.

Implications of the direct observation and the current auditing methodology for hand hygiene compliance results

The potential consequences of the identified limitations of the direct observational data collection methodology may be the gathering and submission of compliance rates which are higher than those that reflect practice in the absence of a human auditor. By way of illustration, Australian national hand hygiene compliance rates have reached a steady state just above the 80% target for several years, with results for the three audit periods in 2017 being 84.6%, 84.3% and 84.8%, and in 2018, 84.6%, 85.1% and 85.4% [55]. It is possible that many practice settings may have reached a natural ceiling on hand hygiene performance as measured using direct observation, having maintained this steady state despite multiple interventions to further improve compliance. This presumed satisfactorily high compliance may be problematic as it could ultimately have the potential for adverse patient outcomes. It may induce complacency with regards to the ongoing need for improvement activities, which in turns may result in inaction in terms of further efforts to improve hand hygiene behaviours and compliance. Such complacency has the potential to place patients at risk if the unbiased hand hygiene compliance rate is accepted as being potentially as low as one third of the submitted rates [39].

Attempts have been made in the Australian context to improve the validity of direct observational auditing under the auspices of HHA as part of the NHHI framework. The Hand Hygiene Australia 5 Moments for Hand Hygiene Manual outlines and standardises the training, auditing practice and ongoing validation of all auditors who submit data to the NHHI [15]. However, despite this rigour there are still questions as to the accuracy of data collected by direct observation [36].

Given the potential for the current results to represent an overestimation of true practice due to the collection methodology, it has been suggested that changing the approach designed to monitor compliance should be considered. While this would be likely to result in an apparent decline in compliance rates, it is contended that such a methodology would result in less bias in the data being collected. It is suggested that the benefits of recording true practice and the consequent ability to identify and correct non-compliant hand hygiene behaviour would outweigh concerns regarding an apparent decline in compliance. Furthermore, this could ultimately impact positively on patient safety by the potential reduction of hand transmission of microorganisms.

Technological opportunities for hand hygiene compliance auditing

Various electronic measures have been suggested as a solution to the limitations identified with the direct observation method for measuring hand hygiene compliance [46,56,57,60]. A variety of approaches have been described in the literature, with the simplest of these systems being those which measure product consumption. This process typically involves the measurement and monitoring of the number of litres of hand hygiene product purchased or used over a given period of time [18,56]. Increased product consumption has been linked to improved hand hygiene compliance [58] and decreased rates of hospital acquired methicillin-resistant S. aureus (MRSA) infection [59]. Related to product consumption methodologies are systems which count dispenser activations, ranging from simple mechanical counters to more complex electronic time and date stamped systems. These systems count a hand hygiene event as having occurred every time a dispenser activation is detected [56,61,62]. While the counting of dispenser activation will provide a trackable hand hygiene occurrence rate, the resultant figure does not provide information as to compliance. As a consequence, several studies have calculated and reported a compliance percentage by dividing an electronically derived dispenser count by the expected estimated hand hygiene occurrence rate (which is adjusted for factors such as acuity, occupancy, staff and department type) [51,63,64].

Another form of electronic surveillance is real-time location tracking systems (RTLS). Although there is now a range of systems with a variety of features [57], the essential components of a RTLS include a tracking badge worn by HCWs, sensors at doorways or around patient zones, and hand hygiene dispenser activations. Thus, the system detects when a HCW enters or exits a predetermined area (such as a patient room) and whether hand hygiene is associated with this event [11,65e67]. In addition, some systems incorporate prompting and/or feedback in the form of visual or auditory alarms when hand hygiene has not occurred [68e70]. It must be noted that the primary aim of many RTLS, particularly systems which incorporate prompts, appears to be the improvement of compliance, rather than as a data collection/monitoring tool [1,71,72].

The use of video-based systems to monitor hand hygiene compliance appears to be less frequently reported in the literature. Video-based systems range from simple recording of practice for later review and feedback [73e75] to more complex systems which incorporate real time feedback from offsite auditors [76,77]. Most appear to involve the placement of cameras, often motion sensitive, outside patient rooms and/or over sinks. This allows for the capture of data relating to hand hygiene compliance linked to room entry and exit, as well as the capacity to link events to specific HCWs, and also to assess hand hygiene technique [11,75,78]. A small number of studies involving video technology have demonstrated capacity to measure hand hygiene compliance according to the 5 Moments. Repurposing of existing footage, such as that recorded for quality improvement during resuscitations, was described by Brooks [79] and Haac [80]. Three additional studies relating to hand hygiene also demonstrated the technical capacity to calculate compliance according to the WHO 5 Moments for hand hygiene. Diller et al. [63]. Sought to validate the denominator data collected by direct observation as part of the local application of the HOW2 study

that sought to establish the number of hand hygiene opportunities in a variety of different clinical settings [22]. While video based compliance measurement was not the intent, its technical capacity was established. Similarly, Clack et al. [81]. utilised body cameras to determine transmission pathways via the hands of HCWs, and also produced footage from which it was possible to audit compliance according to the 5 Moments framework. Finally, Sanchez-Carillo et al. [75]. used recorded footage of hand hygiene practice in a dialysis unit to give 1:1 feedback and improve compliance. These studies demonstrate the potential for vision-based systems to calculate hand hygiene compliance according to the WHO 5 Moments criteria.

Advantages of electronic monitoring systems

General advantages of electronic surveillance systems include enhanced objectivity, the ability to collect large numbers of hand hygiene events on a continuous basis (potentially across all shifts and days of the week depending on the system design), and the possibility for rapid feedback of hand hygiene rates and real time reminders [36,49]. Al Salman et al. [1] contend that an electronic system is of value because it "instils learning patterns" (p. 123), while Boyce [46] states that they are far less labour intensive, and hence costly, than human auditing. Fisher et al. [82]. concur and also cite the lack of "undesired biases" such as selection bias, observer bias and the Hawthorne Effect as other benefits of electronic surveillance methodologies. The large amounts of data that electronic systems can collect over extended or continuous periods, would also be cost prohibitive and impractical via human audits [17,36,82]. Some electronic systems have the primary focus of compliance monitoring, some focus on compliance promotion, and other systems are a combination of the two. A number of studies have demonstrated improved compliance following the introduction of electronic hand hygiene monitoring systems, particularly those where feedback and/or prompting is incorporated [77,82,83]. However, several have also reported that the statistical significance of these increases in compliance are not known or that the outcome measures, such as infection rates, were either not recorded, not reported, or did not change in a statistically significant manner [84,85].

Disadvantages of electronic monitoring systems

Various disadvantages have been identified with electronic surveillance systems. A primary concern is that most rely on proxy indicators such as room entry and exit or product consumption/dispenser activation rather than the WHO 'My 5 Moments' criteria as a measure of compliance. Many of these systems are reported to provide valid and useful data, but the relevance or merit of this as it applies to hybrid models that combine electronic and non-electronic monitoring of hand hygiene behaviours within the 5 Moments has not yet been examined. Those which rely on such proxy metrics are clearly not able to collect data according to the WHO My 5 Moments criteria nor is their output submissible under the NHHI. Some systems claim to assess Moments 1, 4 and/or 5 but again this is often in proxy [1,65]. Moments 2 and 3 are yet to be successfully audited via a non vision based electronic or direct observation human auditor, as no current technology is successfully able to predict or monitor in room hand hygiene behaviour [42,46,82,86].

There are also reported issues of upfront and ongoing systems costs which may make technological options prohibitive in many settings [1,2,46,59]. For example, Armellino et al. [77] describes a cost of $50,000 USD for the installation of an electronic monitoring system for a 17 bed intensive care unit and further, does not report the cost associated with ongoing real-time feedback. The expense of such technologies leads to questions about cost effectiveness and practical viability outside of the research context [47,59,87,88]. Furthermore, in many cases these systems do not permit the assessment of hand hygiene technique, the professional designation of the HCW or perhaps most significantly, the clinical relevance of an episode of hand hygiene [42,52].

Concerns have also been raised in terms of patient privacy in relation to vision based systems [34,43,59]. Various solutions to these concerns have been suggested, including the use of low resolution cameras, camera alignment to reduce the risk of patient identification, 'opt out' clauses, and obtaining patient consent [63,89e91]. It is worth noting however that the use of camera based systems for various quality control activities has been established practice in a number of areas for many years, such as the recording of resuscitations in Emergency Departments for quality and education purposes [79,80]. Furthermore, a number of studies report that in situations where patient consent was sought, objections were rare once the purpose of the recording was explained [81]. Additionally, a study by Raghavendra and Rex [92] in the United Sates found that not only would patients be interested in having their procedures recorded, but that 61% were prepared to pay for it, suggesting that patient concerns about privacy may not be an insurmountable barrier.

The concerns of healthcare workers may present challenges in implementing electronic monitoring technologies. A series of focus groups conducted by Ellingson et al. [68] found that HCW concerns about the "Big Brother implications" (p. 1093) were the most commonly expressed in relation to the introduction of such systems. Common concerns relate to the impacts upon staff privacy and confidentiality, as well as the potentially punitive consequences as a result of any recorded non-compliance [43,93,94]. Haessler [95] warns of the potential erosion of staff trust that may be engendered if preventative strategies are not implemented. These may include participation, consultation and involvement in system design as well as education, executive support, and the development of clear policies and guidelines relating to system and data use, storage and feedback [1,43,68,94].

Combined direct human and indirect video-based methodologies for hand hygiene auditing e The future?

Mahinda [96] argues that monitoring compliance via direct observation is flawed, and suggests that a more appropriate

strategy would be to pursue electronic measures along with a reduction in the volume of direct observational auditing. Azim et al. [54] concur with the need to automate compliance monitoring, suggesting that focus on direct observation should shift from data collection to making auditors "agents for behaviour change" (p.4) by providing reminders to perform hand hygiene to non-compliant staff. Hence there is the dilemma of the currently mandated yet undeniably flawed, potentially inaccurate data collection methodology and the disconnect between this require approach and the promoted emerging technological alternative. While many electronic surveillance systems described in the literature collect valid information per se and have been shown to promote compliance, none are able to collect compliance data consistent with the WHO 5 Moments framework [46,94]. The potential exception is the vision-based systems. However, there are no published works with the primary purpose of compliance monitoring and data collection in manner consistent with the WHO 5 Moments that describe a combination of direct human observational and indirect video surveillance. Ideally such an approach could incorporate the advantages of direct observation including the provision of immediate, contextual feedback, HCW education, and the reinforcement of the importance of hand hygiene as a patient safety activity, with an emphasis on behaviour and culture change. The electronic data collection component of a hybrid system would potentially result in reduction of biases in data collection as well as a reduction in time and associated expense.

Some important future considerations for hybrid approaches comprising of direct human and indirect video-based methods of hand hygiene auditing relate to the technical and methodological specifications that might be required, the efficacy and cost effectiveness of such systems, and most importantly the attitudes of HCW and patients to such approaches. It is envisioned that direct observation would promote positive behaviour change and engagement whilst the electronic component would have the potential to reduce the biases associated data collection via direct observation. Furthermore, the utility of the resulting data and the extent to which it could potentially be collected in an effective and cost-efficient manner could represent significant time and cost savings for healthcare networks. We argue that future research should examine the possibility of obtaining accurate and detailed information regarding hand hygiene compliance and non-compliance using hybrid direct human and indirect video based observation methods, and that this will have the potential to lead to the development of renewed insights and interventions to positively influence hand hygiene behaviour.

Conclusion

Hand hygiene is fundamental to the safety and quality of healthcare. It is undeniably an integral component of infection prevention and control practice. How well hand hygiene is performed is the subject of growing debate nationally and internationally. The limitations of the current mandated method of auditing using direct observation may be overcome using technology. More research is required to examine future innovations in hand hygiene auditing methodology. The investigation, development, trial and evaluation of the utility of possible hybrid direct human and indirect video based observational methods of hand hygiene compliance monitoring are warranted.

Authorship statement

RS established the study concept and the warrant for the manuscript. KMcK and RS drafted the paper, and all authors had critical input.

Conflict of interest

RS is a Senior Editor of Infection, Disease and Health but had no role in the peer review or editorial decision-making of this paper whatsoever. The other authors declare no interests.

Funding

The writing of this paper was supported by a University of Sydney PhD candidate stipend.

Provenance and peer review

Not commissioned; externally peer reviewed.

Ethics

Not applicable as this work is this manuscript involved no human participants.

Acknowledgements

The authors thank Dr Cecilia Li for her assistance with proofreading.

References

[1] Al Salman JM, Hani S, de Marcellis-Warin N, Isa SF. Effectiveness of an electronic hand hygiene monitoring system on healthcare workers' compliance to guidelines. J Infect Public Health 2015;8(2):117e26.

[2] Storey SJ, FitzGerald G, Moore G, Knights E, Atkinson S, Smith S, et al. Effect of a contact monitoring system with immediate visual feedback on hand hygiene compliance. J Hosp Infect 2014;88(2):84e8.

[3] Kingston L, O'Connell NH, Dunne CP. Hand hygiene-related clinical trials reported since 2010: a systematic review. J Hosp Infect 2016;92(4):309e20.

[4] Allegranzi B, Nejad SB, Castillejos GG, Kilpatrick C, Kelley E, Mathai E. Report on the burden of endemic health care-associated infection worldwide. Geneva, Switzerland: World Health Organization; 2011.

[5] Stone PW. Economic burden of healthcare-associated infections: an American perspective. Expert Rev Pharmacoecon Outcomes Res 2009;9(5):417e22.

[6] Suetens C, Hopkins S, Kolman J, Hogberg LD. European Centre for Disease Prevention and Control: point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. Stockholm: European Centre for Disease Prevention and Control; 2013.

[7] Mitchell BG, Shaban RZ, MacBeth D, Wood C-J, Russo PL. The burden of healthcare-associated infection in Australian hospitals: a systematic review of the literature. Infect. Dis. Health 2017;22(3):117e28.

[8] NHMRC. Australian guidelines for the prevention and control of infection in healthcare. National Health and Medical Research Council; 2019. p. 1e329.

[9] Allegranzi B, Nejad SB, Castillejos GG, Kilpatrick C, Kelley E, Mathai E, et al. Report on the burden of endemic health care-associated infection worldwide: a systematic review of the literature. Geneva, Switzerland: World Health Organisation; 2011. p. 2011.

[10] Hassan M, Tuckman HP, Patrick RH, Kountz DS, Kohn JL. Cost of hospital-acquired infection. Hosp Top 2010;88(3):82e9.

[11] Dufour JC, Reynier P, Boudjema S, Soto Aladro A, Giorgi R, Brouqui P. Evaluation of hand hygiene compliance and associated factors with a radio-frequency-identification-based real-time continuous automated monitoring system. J Hosp Infect 2017;95(4):344e51.

[12] Davis CR. Infection-free surgery: how to improve hand-hygiene compliance and eradicate methicillin-resistant Staphylococcus aureus from surgical wards. Ann R Coll Surg Engl 2010;92(4):316e9.

[13] Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. Infect Control Hosp Epidemiol 2011;32(2):101e14.

[14] European Centre for Disease Prevention and Control. Surveillance of healthcare-associated infections in Europe. Stockholm: European Centre for Disease Prevention and Control.; 2012.

[15] Grayson ML, Havers S, Ryan K, Olsen K. Hand hygiene Australia 5 moments for hand hygiene. In: The Australian commission on safety and quality in health care. 5th ed. 2018. p. 1e125.

[16] Dhar S, Tansek R, Dziekan BA, Chevalier TC, Bohlinger CG, Fitch M, et al. Obsever bias in hand hygiene compliance auditing. Infect Control Hosp Epidemiol 2010;31(8):869e70.

[17] Boyce JM, Polgreen PM, Monsalve M, Macinga DR, Arbogast JW. Frequency of use of alcohol-based hand rubs by nurses: a systematic review. Infect Control Hosp Epidemiol 2017;38(2):189e95.

[18] WHO. WHO guidelines on hand hygiene in healthcare. Geneva, Switzerland: World Health Organization; 2009. 2009.

[19] Pittet D, Boyce JM. Hand hygiene and patient care: pursuing the Semmelweis legacy. Lancet Infect Dis 2001;1:9e20.

[20] Pittet D, Allegranzi B, Sax H, Dharan S, Pessoa-Silva CL, Donaldson L, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. Lancet Infect Dis 2006;6(10):641e52.

[21] Pittet D, Allegranzi B, Boyce JM. The World health organization guidelines on hand hygiene in health care and their consensus recommendations. Infect Control Hosp Epidemiol 2009;30(7):611e22.

[22] Steed C, Kelly JW, Blackhurst D, Boeker S, Diller T, Alper P, et al. Hospital hand hygiene opportunities: where and when (HOW2)? The HOW2 benchmark study. Am J Infect Contr 2011;39(1):19e26.

[23] Stewardson A, Sax H, Longet-Di Pietro S, Pittet D. Impact of observation and analysis methodology when reporting hand hygiene data. J Hosp Infect 2011;77(4):358e9.

[24] Gould DJ, Chudleigh J, Drey NS, Moralejo D. Measuring handwashing performance in health service audits and research studies. J Hosp Infect 2007;66(2):109e15.

[25] Lebovic G, Siddiqui N, Muller MP. Predictors of hand hygiene compliance in the era of alcohol-based hand rinse. J Hosp Infect 2013;83(4):276e83.

[26] Diller T, Kelly JW, Steed C, Blackhurst D, Boeker S, Alper P. O016: electronic hand hygiene monitoring for the WHO 5-moments method. Antimicrob Resist Infect Contr 2013;2(S1).

[27] Sunkesula VC, Kundrapu S, Donskey CJ. Response to the letter to the editor regarding comparison of hand hygiene monitoring using the my 5 moments for hand hygiene method versus the wash in-wash out method. Am J Infect Contr 2015;43(8):902.

[28] Masroor N, Doll M, Stevens M, Bearman G. Approaches to hand hygiene monitoring: from low to high technology approaches. Int J Infect Dis 2017;65:101e4.

[29] Talbot TR, Johnson JG, Fergus C, Domenico JH, Schaffner W, Daniels TL, et al. Sustained improvement in hand hygiene adherence: utilizing shared accountability and financial incentives. Infect Control Hosp Epidemiol 2013;34(11):1129e36.

[30] Chen YC, Sheng WH, Wang JT, Chang SC, Lin HC, Tien KL, et al. Effectiveness and limitations of hand hygiene promotion on decreasing healthcare-associated infections. PLoS One 2011;6(11):e27163.

[31] Grayson ML, Stewardson AJ, Russo PL, Ryan KE, Olsen KL, Havers SM, et al. Effects of the Australian National Hand Hygiene Initiative after 8 years on infection control practices, health-care worker education, and clinical outcomes: a longitudinal study. Lancet Infect Dis 2018;18(11):1269e77.

[32] Pittet D, Boyce JM. Hand hygiene and patient care: pursuing the Semmelweis legacy. Lancet Infect Dis 2001;1(Supplement 1):9e20.

[33] Kavanagh KT, Saman DM. Comment regarding Electronic hand hygiene monitoring as a tool for reducing health care-associated methicillin-resistant Staphylococcus aureus infection. Am J Infect Contr 2016;44(12):1761e2.

[34] Palmore TN, Henderson DK. Big brother is washing. Video surveillance for hand hygiene adherence, through the lenses of efficacy and privacy. Clin Infect Dis 2012;54(1):8e9.

[35] Scheithauer S, Batzer B, Dangel M, Passweg J, Widmer A. Workload even affects hand hygiene in a highly trained and well-staffed setting: a prospective 365/7/24 observational study. J Hosp Infect 2017;97(1):11e6.

[36] McLaws ML, Kwok YLA. Hand hygiene compliance rates: fact or fiction? Am J Infect Contr 2018;46(8):876e80.

[37] Australian Commission on Safety and Quality in Health Care. National saftey and quality health service standards. 2nd ed. Sydney, NSW, Australia: Australian Commission on Safety and Quality in Health Care; 2017.

[38] Daniels TL. Reconsidering hand hygiene monitoring. J Infect Dis 2012;206(10):1488e90.

[39] Srigley JA, Furness CD, Baker GR, Gardam M. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. BMJ Qual Saf 2014;23(12):974e80.

[40] Council of Australian Governments. Health and hospital funding: austrarlian government. Council of Australian Governments meeting Communiqué; 2016. 9 December 2016]. Available from: https://www.coag.gov.au/.

[41] Pan SC, Tien KL, Hung IC, Lin YJ, Sheng WH, Wang MJ, et al. Compliance of health care workers with hand hygiene practices: independent advantages of overt and covert observers. PLoS One 2013;8(1). e53746.

[42] Hagel S, Reischke J, Kesselmeier M, Winning J, Gastmeier P, Brunkhorst FM, et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. Infect Control Hosp Epidemiol 2015;36(8):957e62.

[43] Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Contr 2017;45(5):528e35.

[44] Fries J, Segre AM, Thomas G, Herman T, Ellingson K, Polgreen PM. Monitoring hand hygiene via human observers: how should we be sampling? Infect Control Hosp Epidemiol 2012;33(7):689e95.
[45] Parsons HM. What happened at Hawthorne? Science 1974; 183(4128):922e32.
[46] Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Contr 2017;45(2017):528e35.
[47] Gould DJ, Creedon S, Jeanes A, Drey NS, Chudleigh J, Moralejo D. Impact of observing hand hygiene in practice and research: a methodological reconsideration. J Hosp Infect 2017;95(2):169e74.
[48] Stackelroth J, Shaban RZ. The challenges of implementing a national hand hygiene initiative in rural and remote areas: is it time for a new approach to auditing? Healthc Infect 2011; 16(2):63e70.
[49] Srigley JA, Lightfoot D, Fernie G, Gardam M, Muller MP. Hand hygiene monitoring technology: protocol for a systematic review. Syst Rev 2013;2(101):101.
[50] Kohli E, Ptak J, Smith R, Taylor E, Talbot EA, Kirkland KB. Variability in the Hawthorne effect with regard to hand hygiene performance in high- and low-performing inpatient care units. Infect Control Hosp Epidemiol 2009;30(3): 222e5.
[51] Azim S, Juergens C, Hines J, McLaws ML. Introducing automated hand hygiene surveillance to an Australian hospital: mirroring the HOW2 benchmark study. Am J Infect Contr 2016; 44(7):772e6.
[52] Boyce JM. Hand hygiene compliance monitoring: current perspectives from the USA. J Hosp Infect 2008;70(Suppl 1): 2e7. S1.
[53] Boyce JM, Cooper T, Dolan MJ. Evaluation of an electronic device for real-time measurement of alcohol-based hand rub use. Infect Control Hosp Epidemiol 2009;30(11):1090e5.
[54] Azim S, McLaws ML. Doctor, do you have a moment? National Hand Hygiene Initiative compliance in Australian hospitals. Med J Aust 2014;200(9):534e7.
[55] Hand hgyiene Australia [Internet]. Available from: https://hhcapp.hha.org.au/en_AU/HHA/dashboard; 2018.
[56] Boyce JM. Measuring healthcare worker hand hygiene activity: current practices and emerging technologies. Infect Control Hosp Epidemiol 2011;32(10):1016e28.
[57] Cantrel S. Electronic hand-hygiene systems take compliance to the next level. Healthc Purch News 2016 Octber:24e9. 2016.
[58] Cheng VC, Tai JW, Chan WM, Lau EH, Chan JF, To KK, et al. Sequential introduction of single room isolation and hand hygiene campaign in the control of methicillin-resistant Staphylococcus aureus in intensive care unit. BMC Infect Dis 2010;10(263):263.
[59] Gould DJ, Drey NS, Creedon S. Routine hand hygiene audit by direct observation: has nemesis arrived? J Hosp Infect 2011; 77(4):290e3.
[60] Marra AR, Moura Jr DF. Paes AT, dos Santos OF, Edmond MB. Measuring rates of hand hygiene adherence in the intensive care setting: a comparative study of direct observation, product usage, and electronic counting devices. Infect Control Hosp Epidemiol 2010;31(8):796e801.
[61] McGurkin M, Govednik J. A review of electronic hand hygiene monitoring: considerations for hospital management in data collection, healthcare worker supervision, and patient perception. J Healthc Manag 2015;60(5):348e61.
[62] Kwok YLA, Juergens CP, McLaws M-L. Automated hand hygiene auditing with and without an intervention. Am J Infect Contr 2016;44(2016):1475e80.
[63] Diller T, Kelly JW, Blackhurst D, Steed C, Boeker S, McElveen DC. Estimation of hand hygiene opportunities on an adult medical ward using 24-hour camera surveillance: validation of the HOW2 benchmark study. Am J Infect Contr 2014; 42(6):602e7.
[64] Arai A, Tanabe M, Nakamura A, Yamasaki D, Muraki Y, Kaneko T, et al. Utility of electronic hand hygiene counting devices for measuring physicians' hand hygiene adherence applied to outpatient settings. Am J Infect Contr 2016;44(12):1481e5.
[65] Cheng VC, Tai JW, Ho SK, Chan JF, Hung KN, Ho PL, et al. Introduction of an electronic monitoring system for monitoring compliance with Moments 1 and 4 of the WHO "My 5 Moments for Hand Hygiene" methodology. BMC Infect Dis 2011;11(151):151.
[66] Monsalve MN, Pemmaraju SV, Thomas GW, Herman T, Segre AM, Polgreen PM. Do peer effects improve hand hygiene adherence among healthcare workers? Infect Control Hosp Epidemiol 2014;35(10):1277e85.
[67] Sahud AG, Bhanot N, Narasimhan S, Malka ES. Feasibility and effectiveness of an electronic hand hygiene feedback device targeted to improve rates of hand hygiene. J Hosp Infect 2012; 82(4):271e3.
[68] Ellingson K, Polgreen PM, Schneider A, Shinkunas L, Kaldjian LC, Wright D, et al. Healthcare personnel perceptions of hand hygiene monitoring technology. Infect Control Hosp Epidemiol 2011;32(11):1091e6.
[69] Filho MA, Marra AR, Magnus TP, Rodrigues RD, Prado M, de Souza Santini TR, et al. Comparison of human and electronic observation for the measurement of compliance with hand hygiene. Am J Infect Contr 2014;42(11):1188e92.
[70] Levchenko AI, Boscart VM, Fernie GR. The effect of automated monitoring and real-time prompting on nurses' hand hygiene performance. Comput Inform Nurs 2013;31(10): 498e504.
[71] Swoboda SM, Earsing K, Strauss K, Lane S, Lipsett PA. Isolation status and voice prompts improve hand hygiene. Am J Infect Contr 2007;35(7):470e6.
[72] Venkatesh AK, Lankford MG, Rooney DM, Blachford T, Watts CM, Noskin GA. Use of electronic alerts to enhance hand hygiene compliance and decrease transmission of vancomycin-resistant Enterococcus in a hematology unit. Am J Infect Contr 2008;36(3):199e205.
[73] Shah R, Patel DV, Shah K, Phatak A, Nimbalkar S. Video surveillance audit of hand-washing practices in a neonatal intensive care unit. Indian Pediatr 2015;52(5):409e11.
[74] Brown J, Friese-Fretz A, Luckey D, Todd JK. High rate of hand contamination and low rate of hand washing before infant contactin a neonatal intensive care unit. Pediatr Infect Dis J 1996;15(10):908e10.
[75] Sanchez-Carrillo LA, Rodriguez-Lopez JM, Galarza-Delgado DA, Baena-Trejo L, Padilla-Orozco M, Mendoza-Flores L, et al. Enhancement of hand hygiene compliance among health care workers from a hemodialysis unit using video-monitoring feedback. Am J Infect Contr 2016;44(8): 868e72.
[76] Armellino D, Trivedi M, Law I, Singh N, Schilling ME, Hussain E, et al. Replicating changes in hand hygiene in a surgical intensive care unit with remote video auditing and feedback. Am J Infect Contr 2013;41(10):925e7.
[77] Armellino D, Hussain E, Schilling ME, Senicola W, Eichorn A, Dlugacz Y, et al. Using high-technology to enforce low-technology safety measures: the use of third-party remote video auditing and real-time feedback in healthcare. Clin Infect Dis 2012;54(1):1e7.
[78] Stackelroth J, Sinnott M, Shaban RZ. Hesitation and error: does product placement in an emergency department influence hand hygiene performance? Am J Infect Contr 2015; 43(9):913e6.
[79] Brooks AJ, Phipson M, Potgieter A, Koertzen H, Boffard KD. Education of the trauma team: video evaluation of the

compliance with universal barrier precautions in resuscitation. Eur J Surg 1999;165(12):1125e8.
[80] Haac B, Rock C, Harris AD, Pineles L, Stein D, Scalea T, et al. Hand hygiene compliance in the setting of trauma resuscitation. Injury 2017;48(1):165e70.
[81] Clack L, Scotoni M, Wolfensberger A, Sax H. First-person view of pathogen transmission and hand hygiene - use of a new head-mounted video capture and coding tool. Antimicrob Resist Infect Contr 2017;6:108.
[82] Fisher DA, Seetoh T, Oh May-Lin H, Viswanathan S, Toh Y, Yin WC, et al. Automated measures of hand hygiene compliance among healthcare workers using ultrasound: validation and a randomized controlled trial. Infect Control Hosp Epidemiol 2013;34(9):919e28.
[83] Boscart VM, McGilton KS, Levchenko A, Hufton G, Holliday P, Fernie GR. Acceptability of a wearable hand hygiene device with monitoring capabilities. J Hosp Infect 2008;70(3):216e22.
[84] Ellison 3rd RT, Barysauskas CM, Rundensteiner EA, Wang D, Barton B. A prospective controlled trial of an electronic hand hygiene reminder system. Open Forum Infect Dis 2015;2(4). ofv121.
[85] Conway LJ, Riley L, Saiman L, Cohen B, Alper P, Larson EL. Implementation and impact of an automated group monitoring and feedback system to promote hand hygiene among health care personnel. Jt Comm J Qual Patient Saf 2014;40(9):408e17.
[86] Momen K, Fernie GR. Nursing activity recognition using an inexpensive game controller: an application to infection control. Technol Health Care 2010;18(6):393e408.
[87] Ward MA, Schweizer ML, Polgreen PM, Gupta K, Reisinger HS, Perencevich EN. Automated and electronically assisted hand hygiene monitoring systems: a systematic review. Am J Infect Contr 2014;42(5):472e8.
[88] Neo JR, Sagha-Zadeh R, Vielemeyer O, Franklin E. Evidence-based practices to increase hand hygiene compliance in health care facilities: an integrated review. Am J Infect Contr 2016;44(6):691e704.
[89] Xiao Y, Seagull FJ, Bochicchio GV, Guzzo JL, Dutton RP, Sisley A, et al. Video-based training increases sterile-technique compliance during central venous catheter insertion. Crit Care Med 2007;35(5):1302e6.
[90] Hu YY, Peyre SE, Arriaga AF, Osteen RT, Corso KA, Weiser TG, et al. Postgame analysis: using video-based coaching for continuous professional development. J Am Coll Surg 2012;214(1):115e24.
[91] Weinger MB, Gonzales DC, Slagle J, Syeed M. Video capture of clinical care to enhance patient safety. Qual Saf Health Care 2004;13(2):136e44.
[92] Raghavendra M, Rex DK. Patient interest in video recording of colonoscopy: a survey. World J Gastroenterol 2010;16(4):458e61.
[93] Srigley JA, Gardam M, Fernie G, Lightfoot D, Lebovic G, Muller MP. Hand hygiene monitoring technology: a systematic review of efficacy. J Hosp Infect 2015;89(1):51e60.
[94] Conway LJ. Challenges in implementing electronic hand hygiene monitoring systems. Am J Infect Contr 2016;44(5 Suppl). e7-e12.
[95] Haessler S. The Hawthorne effect in measurements of hand hygiene compliance: a definite problem, but also an opportunity. BMJ Qual Saf 2014;23(12):965e7.
[96] Mahida N. Hand hygiene compliance: are we kidding ourselves? J Hosp Infect 2016;92(4):307e8.

Appendix B: McKay, K.J., Ferguson, P.E., Shaban, R.Z. (2021). Methodological and technical considerations for video-based auditing of hand hygiene compliance: an exploratory study. American Journal of Infection Control. 49(11), pp. 1384-91. Doi.org/10.1016.ajic.2021.04.081.

American Journal of Infection Control 49 (2021) 1384–1391

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Methodological and technical considerations for video-based auditing of hand hygiene compliance in clinical practice: an exploratory study

Katherine J. McKay MAdClinPrac(PP) (Hons) [a,b,*], Patricia E. Ferguson PhD [c,d], Ramon Z. Shaban PhD [b,c,e,f]

[a] Infection Prevention and Control, Eastern Health, Box Hill, Victoria, Australia
[b] Faculty of Medicine and Health, Susan Wakil School of Nursing and Midwifery, University of Sydney, Camperdown, NSW, Australia
[c] Marie Bashir Institute for Infectious Diseases and Biosecurity, Faculty of Medicine and Health, University of Sydney, NSW, Australia
[d] Center for Infectious Diseases and Microbiology, Westmead Hospital, Western Sydney Local Health District, Westmead, NSW, Australia
[e] Department of Infection Prevention and Control, Division of Infectious Diseases and Sexual Health, Westmead Hospital and Western Sydney Local Health District, Westmead, NSW, Australia
[f] New South Wales Biocontainment Centre, Western Sydney Local Health District and New South Wales Health, NSW, Australia

Key Words:
Hand Hygiene
Compliance
Direct Observation
Audit
Video Surveillance
Technology

Background: Direct observation is the gold standard method for measuring hand hygiene compliance but its utility is increasingly being questioned. Various alternative electronic methods have been proposed, yet there is a paucity of research examining the use of these according to the World Health Organization's (WHO) '5 Moments for Hand Hygiene'. As a part of the process of developing a video-based monitoring system (VMS) capable of measuring hand hygiene compliance against the 5 moments criteria this paper reports methodological and technical issues that might arise from the use of a VMS for auditing in clinical practice.

Methods: In-depth semi-structured interviews were conducted with 27 Australian content experts in hand hygiene auditing and infection prevention to explore their responses to proposed VMS auditing approaches. Transcripts were analyzed using thematic and content analysis.

Results: Technical and methodological considerations for the use of VMS were interrelated and included concerns surrounding privacy, footage security, fears of surveillance and the potential for medico-legal consequences. Additionally, possible detrimental impacts on healthcare worker (HCW) -patient relationships, issues of cost versus benefits, HCW and patient safety and changes to feedback were also identified.

Conclusions: The primary methodological and technical issues to overcome in order to implement VMS for hand hygiene auditing in clinical practice, centered upon issues of acceptability to patients and health professionals, privacy, consent and liability.

Checklist: COREQ

BACKGROUND

Hand hygiene is arguably the single most important action that a healthcare worker (HCW) can undertake to prevent patients in their care from acquiring a healthcare-associated infection (HAI)[1]. The link between improved hand hygiene compliance and decreasing HAIs has been demonstrated.[1,2–4] The timing of hand hygiene in relation to patient contact is critical to interrupt the transmission of microorganisms as outlined by the WHO '5 Moments for Hand Hygiene'.[1] The '5 Moments' also provide a structured framework against which hand hygiene compliance can be measured, with direct observation deemed to be the 'gold standard'.[1,5,6] Essentially, this process involves an auditor being present in the clinical environment and observing HCW-patient care interactions. A compliance rate is derived by dividing the number of times which hand hygiene occurred according to the '5 Moments' by the number of times it should have occurred.[1,5]

* Address correspondence to: Katherine McKay, MAdClinPrac(PP) (Hons), 39 Velma Grove, Ringwood East, Victoria 3135, Australia
E-mail address: Kmck4637@uni.sydney.edu.au (K.J. McKay).

Conflict of Interest: None to report.
Funding/support: This study was supported by a University of Sydney PhD candidate stipend, and research grant funding from the Marie Bashier Institute for Infectious Disease and Biosecurity at the University of Sydney.
Authors contrivutions: RZS established the study concept and the warrant for the manuscript. KMc and RZS drafted the paper, and all authors had critical input.

https://doi.org/10.1016/j.ajic.2021.04.081
0196-6553/

Direct observation is seen as advantageous as it enables the measurement of hand hygiene practice according to each of the 5 moments as well as by HCW designation. It allows for the assessment of technique and glove usage as well as the identification of barriers to compliance such as product placement or availability.[7,8] The physical presence of the auditor can highlight the importance of hand hygiene and may have a cueing effect on HCW behavior.[9,10] It is easily adaptable to many different settings and is seen by some as a low-cost approach, particularly in resource limited situations.[1,11] Perhaps the most highly rated advantage of the method is the ability of auditors to provide immediate, contextual 'on the spot' feedback and education to those who are the subject of the audit, which may in turn lead to improved compliance.[10,12]

Despite the acknowledged benefits, questions about the suitability of direct observation as a data collection methodology have been raised.[13–15] An alternative view sees it as a time consuming and expensive way to collect what amounts to relatively small and statistically underpowered snapshots of hand hygiene behavior that are insufficiently sensitive to detect compliance trends.[12,16,17] There are questions relating to inter-auditor reliability and auditor skill adversely impacting on the accuracy of the data. A major criticism is that the methodology results in a significant, yet temporary inflation of the compliance rate for HCW hand hygiene, due to a variety of biases, including (1) observer bias (where the auditor has a preconceived expectation of compliance); (2) selection bias (where the auditor elects to audit only certain staff or at certain times of the day) and most notably; (3) observation bias, or the Hawthorne effect, (where those being observed change their behavior, increasing compliance due to the presence of the observer).[9,18]

Various electronic methods, reported to be free of these and other limitations of direct observation, have been suggested as alternatives. They tend to fall into three broad categories: (1) those which focus on an event rate via product consumption or dispenser activation; (2) those which calculate compliance via proximity eg linking entry or exit to dispenser activation; and (iii) video-based monitoring systems (VMS) with remote auditing from recorded footage.[11,19,20] Although VMS has been touted in the literature and a number of studies suggest that such systems are technically capable of monitoring all 5 moments.[21–23]no system with this technical capacity and/or primary aim has been described. This paper reports the results of a study that examined the methodological and technical issues that might arise from the use of a VMS for hand hygiene auditing and which may need to be considered prior to the implementation of such technology.

METHODS

Study design

In-depth semi- structured interviews within a pragmatic naturalistic theoretical framework were utilized in this study.

Study Setting and Participants

The study was conducted in Australia with participants from the membership of the Australasian Collage of Infection Prevention and Control (ACIPC). Recruitment was via invitational email mediated by ACIPC and the hand hygiene co-ordinator of a large metropolitan health care network. Volunteer participants were sought from four classifications of hand hygiene compliance expertise in order to provide rich information as a consequence of their background, knowledge and experience[24]: (1) Content Experts (CE) n = 5; (2) Hand Hygiene Program Managers (MOD) n=16; (3) Frontline Data Collectors (COD) n = 4; and (4) Departmental mangers who receive and act upon hand hygiene results (ROD) n = 2. The use of a wide range of informants from a variety of settings provided triangulation of data sources and enhanced credibility.[25,26]

Data Collection and Analysis

Following written consent, semi-structured interviews were conducted by one researcher (KMc) with the 27 participants between June and October 2019. Interviews were conducted either in person, online or by telephone depending on the participants' geographical location and personal preferences and lasted between 20 and 50 minutes. Participants were from a range of metropolitan and regional, acute, sub-acute and community health settings. Interviews included questions about both current direct observation and the proposed VMS auditing methods and were audio recorded with the consent of all participants. A question guide (Appendix 1) was used and was modified as the interviews progressed based upon concurrent analysis, which suggested new or expanded areas to explore with subsequent participants.[24] This preliminary form of analysis can, should and indeed did, guide further data collection.[27] The use of open-ended questions encouraged discussion and expansion of ideas and allowed rich data to emerge. Interviews were audio recorded and transcribed verbatim by the Researcher (KMc) which aided immersion in and engagement with the data.[28] Sequential transcription also supported the iterative nature of the approach, allowing the researcher to move back and forth from data collection to analysis. Member checking was undertaken to enhance reliability of the data, for example, transcripts were returned to participants to review and confirmation of ideas between participants was sought to assist in establishing normative responses.[25,26]

The data from interviews underwent content and thematic analysis.[29] This form of analysis is commonly used in nursing and healthcare research[30] and is a favorable method as it is content selective and applicable to many different research designs. The use of an open coding system guided by the semi-structured questions allowed for the generation of categories which helped to describe and understand the data, resulted in the emergence of links or relationships and helped to ensure the credibility of the data.[25,27,30] In general, technical issues were seen as those which related to the physical process of capturing, storing, auditing and disposing of the data, while methodological considerations included policy, legislative, psychosocial and interpersonal issues associated with this form of data collection, however the division between the 2 classifications was not concrete. Initially the themes which emerged were quite broad, however, prolonged engagement with the data as well as the use of diagramming helped to make sense of the connections and allowed themes to be condensed to represent conceptual units of meaning which were linked to the same phenomena or idea.[27,28,31] Peer review by senior members of the team (RZS and PF) and regular team debriefing between all researchers supported the identification of any biases and aided conceptual development. The analysis of the resultant thematic categories enabled identification of (1) the clinicians' views, understandings and expectations of a VMS; (2) the quantification of the frequency with which these ideas and concepts were raised; and iii) an understanding of the importance and meaning attributed to these parameters.

Ethical considerations

The study was conducted in accordance with the ethics approval granted by the Human Research Ethics Committee (HREC) of the University of Sydney (approval number 2019/387).

RESULTS

There is a complex interdependent array of technical and methodological issues associated with the use of VMS for hand hygiene auditing in healthcare, which are represented here in eight interconnected themes;

Patient privacy

Patient privacy, and possible breaches therein, was the most significant issue with using VMS for hand hygiene auditing. Most believed this would be the primary obstacle for all concerned:

> "Well I think it's mostly about privacy, that's going to be the biggest issue" [MOD10].

Contrasting beliefs and thoughts emerged relating to patient privacy. Some participants thought that patients would be very unhappy about the idea of being filmed, whilst others felt that once they understood the purpose of the VMS, patients would not object:

> "I think if patients knew that this was purely for … auditing purposes… and it's just monitoring staff's behaviors to ensure compliance to safe nursing practice… I don't see why it would be an issue… I think you could quite easily bring the patients over" [COD2].

Obtaining consent was seen as an important way of overcoming concerns regarding any invasion of patient privacy. Confirming that patients were aware of, had understood and had agreed to the process was seen as vital;

> "Knowing that the patient in the bed at the time had agreed to being filmed and they had an understanding about how this was going to work and why" [CE5].

The question of whether consent would be required was raised with reference to current practices of video recording. Several participants described their experiences with and acceptance of similar technology in healthcare, such as cameras in the emergency department, body cameras for security staff, telehealth systems and cameras for falls prevention in aged care.

> "We do have CCTV in this facility… we have got CCTV everywhere … which we use from time to time" [MOD3].

The ability of patients to 'opt out', either entirely or intermittently, was seen as another way of ensuring patient respect as part of the process. This might constitute total non-participation in the auditing process, in that no filming would take place, or alternatively may involve discontinuation of filming at certain times upon request.

> "The patient needs to be able to be provided with the opportunity to flick the camera off at any particular time" [CE2].

While patient privacy was touted as a major concern by a significant proportion of participants, there were also those who believed that this would be offered as an excuse by those HCWs whose real concern was their own privacy.

> "The first one they would fall back on .. would be … the… the patient's privacy… um … that would be the first one… and I think they would use that as a barrier to their own fear of being recorded" [MOD7].

Data security and confidentiality

The second theme encompassed concerns surrounding footage confidentiality and security, which was also related to both patient privacy and the third theme, that of fear of surveillance. Participants stressed the importance of reassurance about the form, location, security, storage and length of retention of the recorded footage. Although these concerns related primarily to staff, the security of patient data was also raised with one participant noting that they often had "high profile" [MOD3] patients who needed to be shielded from publicity. As several participants commented, it would be important for all concerned that the footage would not end up on social media:

> "Is there the possibility that it would ever get leaked and end up on Facebook or something like that?" [CE3].

There were also concerns about who would have access to the footage. Various acceptable caveats were suggested, "only certain people" [MOD4] and "someone who is totally independent" and is "locked into a confidentiality agreement" [MOD15]. The general consensus seemed to be for "limiting the number of staff who actually see the footage" [CE4] and for ensuring that those who did maintained strict confidentiality. As a rule, Infection Prevention and Control (IPAC) staff and qualified and validated auditors were seen as appropriate individuals to view the footage. A common view was that managers, executives, peers and colleagues should not have access:

> "We would have to have guarantees only IPAC… infection control… will see the footage… not your manager… not your colleagues … not … cause that would be the LAST thing you'd want" [MOD12].

The importance attributed to data security is symptomatic of the next theme, that being a fear of surveillance.

Fear of 'surveillance'

The phrase "Big Brother" was used by many participants to express their concerns and nervousness about a VMS:

> "It just feels very … "Big Brotherish" … mmm … not very personal … I can just imagine if I said to my staff (laughs) … they'd be saying … you know… you're just looking at everything we do and judging us all the time" [MOD11].

Participants spoke of how "everyone's scared that they're doing the wrong thing" [CE1] and that staff would believe that if they made a mistake that they would "get into trouble" [MOD11], be "hung out to dry" [CE2], or face "instant dismissal" [COD2]. Concerns that the use of video-based auditing would lead to an inappropriate and unwelcome focus on individuals, of being "named and shamed" [MOD12] or having their names appear in "the board report" [MOD12] were also reported. While such a response to non-compliance with hand hygiene is highly unlikely, and does not occur with current auditing, it is clear that these beliefs are held and as such may constitute a significant barrier to acceptance of VMS hand hygiene auditing. These responses served to illuminate the existence of a punitive culture in healthcare described by several participants:

> "We might like to think in an ideal world… this is not punitive… but the reality is the system likes to 'big stick' rather than 'carrot'" [ROD2].

Participants expressed the need for assurances that there would be no 'punishment' or 'public shaming' for non-compliance detected via a VMS. It was also stressed that compliance rates collected this way should only be made public in such a way that identification of individuals was precluded.

Participants stressed that while it was indeed reasonable to follow up serious incidents, there was a need to give assurances that such feedback would be provided in a confidential, supportive, no-blame, 1:1 manner where staff could be given a chance to reflect upon and learn from errors, as noted below:

> "If there was a circumstance where I didn't follow best practice ... that I was ... that I had the opportunity to explain why" [CE2].

In order to reassure staff and help to improve acceptance of the auditing methodology, it was suggested that there be codification of the management of observed serious non-compliance, including the clarification of what would constitute a "serious breach" or incident.

Concerns relating to 'other' and potentially negative uses to which the footage might be put, were raised by participants. Some felt it would be essential to guarantee that a proposed VMS would only be used for hand hygiene auditing purposes.

> "We'd have to prove we're not aiming for anything other than hand hygiene... that the material that is used will not be used against them" [MOD10].

It was also suggested that these guarantees would need to be in the form of "some documentation or evidence" [ROD1] or even "like a piece of paper with written things on it and signed" [MOD14] ensuring that the technology and the resultant footage would only be used as agreed. In particular, participants indicated that it would be important to provide specific assurances that the footage would not "be used in staff appraisals" [COD1] and that it was "not gonna be used for performance reviews" [MOD2], nor would it "be used as a record for that staff member to be used by anyone down the road" [MOD7].

Assurances as to deletion of the footage following auditing were seen as a vital factor that should be incorporated in any auditing methodology:

> "Guarantee that it would be destroyed after a certain amount of time which ... that it couldn't be used" [MOD7].

The importance of staff being involved with implementation of VMS and ensuring that they had a full understanding as to "how it would work" [CE5] was also highlighted. Phrases such as "communication", "engagement", "buy-in", "consultation" and "change management roll out" were common in terms of ways to improve staff acceptance and overcome feelings of 'Big Brother'. Participants stated that being honest and open, and clearly outlining the purpose as well as the technical and methodological parameters of the VMS was crucial to overcome concerns about surveillance.

> "Listening to people's concerns and not necessarily having that answer.. um... "I hear your concerns" and it's not just a case of "look just be reasonable, everyone's doing it... it... it's the way of the future ... just get over yourself" .. but "what we are trying to do here is this..." and trying to find some common ground with them" [ROD2].

Liability and medico-legal risk

As well as fears associated with being monitored at work, participants also expressed concern about the potential legal ramifications of the use of the footage by patients and/or their relatives.

> "Doctors will be extremely concerned I think... whether it can impact of them ... you know... to be sued ... or whether it comes under freedom of information" [CE4].

Participants' concerns were not only for themselves, but also for their organizations:

> "If something's picked up on the video that would be viewed ... um... you know ... in a not favorable light ... such as a negligent activity or something going wrong ... what happens with that from a legal perspective ... ... or you know from an organizational perspective ... could it be used against the organization?" [MOD4].

Effect on professional and therapeutic relationships

The impact of VMS on a variety of relationships was raised by several participants. Some felt that cameras would make the auditing process less personal and more objective. Others suggested that the use of VMS would indicate to clinicians that neither management nor the IPAC service 'trusted' them to practice hand hygiene correctly, and entrench views that the IPAC Service was like the police:

> "Would staff turn around and think that we're not trusting them... I think... you know ... would we lose face ... would our staff lose faith in in our system if they knew they were being videoed" [MOD5].

One participant became quite passionate about the idea of cameras, even suggesting that their use would lead HCWs to feel that their professionalism was being questioned.

> "If you're being constantly monitored for the job you do ... I don't know... if that's like... where's the trust gone that we are trained, qualified professionals ... staff would see it as more of a judgement on their abilities and their training ... and their professionalism" [COD1].

There were also concerns that auditing via video might mean less time or presence in the clinical environment and that this could negatively impact on the IPAC-HCW relationship.

> "They get to know you're around and you're not just this person who sits in an office all the time on a computer... you've got some interaction and recognition ... that gives you a profile as well so you wouldn't be getting that if you're doing it all by video" [MOD15].

Conversely other participants described relief that they would not be required to undertake as much direct observational auditing, describing it as "the most loathsome part of our job" [MOD7] and relating how they felt like "some sort of staff general walking up and down" [MOD10]. This in turn they reasoned negatively impacted on professional relationships between auditor and audited HCW.

The potential for the presence of cameras to impact adversely upon the HCW-patient relationship was also raised. Participants' primary concern was that the cameras may cause staff to "get a bit more on edge" [COD2] and become overly focused on hand hygiene, thus resulting in a disruption to both concentration and technical ability.

"You don't want any of the staff to feel uncomfortable so that it alters their… anything in their clinical interaction with the patients" [CE1].

Others discounted this risk, suggesting that the presence of cameras might be beneficial in that staff would strive for best practice:

"Some people will see the video and think "Oh God… I'm being filmed… I better do it right"" [CE3].

Similarly, cameras were thought to lessen the likelihood of negative patient behaviors:

"It could be supportive as well… sometimes when you have patients that are difficult… it could be supportive towards the clinical staff" (MOD5)

Notwithstanding, many participants suggested that cameras might make staff reluctant to enter patient rooms for fear of being filmed which could in turn impact negatively on patient care.

Cost benefit

The question as to whether VMS auditing would be more expensive than direct observation was raised by a number of participants. Some were firmly of the belief that such approaches would not represent a saving of either time or money, hence placing the approach beyond the reach of many healthcare services. As well as the expense of the infrastructure, the potential for an increased time burden was highlighted.

"I think that mainly the time… the time that you would need to spend reviewing the footage" [CE4]

Others suggested that VMS could yield savings, such as fewer auditor numbers, the ability to audit remote locations, the capacity to put cameras to multiple uses and the increased speed with which moments could be gathered:

"You can speed through if nothing 's going on so you're not standing there for 4 hours to get 5 moments" [MOD1]

Several participants argued that gathering hand hygiene data compliance via VMS would make change strategies more effective which, they reasoned, could lead to a true improvement in hand hygiene compliance, thereby reducing HAIs and improving patient safety.

Improving patient safety

Many participants suggested that a VMS would have the ability to introduce major improvements in patient safety. This was because VMS data was perceived as being more accurate, more "true to life" [MOD14] and not reliant on "human judgement" [MOD6]. It was suggested that VMS could be used for auditing other infection control measures:

"It would … you know… be potentially a one stop shop for observing compliance with infection control as a whole" [MOD5].

Participants suggested that a VMS could assist in the auditing of glove use, transmission-based precautions and aseptic non-touch technique. It was noted that as well as the infection control focus, a VMS could be put to other uses such as "suicide watch", falls prevention or even;

..to see if patients are actually tampering with their IV's as… you'd be able to get a bit more information" [MOD5].

Following appropriate consent, it was suggested that de-identified video footage could also assist in optimizing workflows, identify product placement issues and also be developed into educational materials, all of which would have the potential to improve patient care.

Feedback for practice improvement

The concept of VMS gave rise to issues regarding the ability to give feedback. The lack of immediate feedback was seen as a problem, potentially leading to a lack of ownership of non-compliant behaviors hence making auditing less productive:

"I don't think it would help because you're not getting that direct feedback, because if you're doing video … there's nobody immediately involved … they'd have to go away and get looked at… then the feedback would be … you know … days … weeks later and people have forgotten what they were doing … it loses that direct feedback and education" [MOD11].

Conversely many reported that being able to review one's own behaviors was seen as a very powerful learning opportunity, particularly for those who were perceived as visual learners;

"There's so much to be learnt from people watching their own practice and being able to see the things that they can do" [CE1].

It was suggested that showing staff where they could improve by reviewing the recorded footage together could provide more meaningful feedback than a verbal explanation from a hand hygiene auditor in the midst of a busy clinical day. However, it was also made clear that this option would not be something that all staff would be comfortable with as some HCWs were described as having a "fear of reflexivity" [ME2]. This led to suggestions that the receipt of such 1:1 feedback should only be provided at the request of the individual HCW themselves. Having this option would enable staff to feel safer and more accepting of the approach as "you give staff an element of control" [ROD2].

It was also highlighted that the codification of the feedback process would be an essential element of acceptance of the VMS. Staff would need to clearly understand how, when and in what form feedback would be given.

"What sort of feedback they could expect… would it just be the same as currently or would there be some sort of different feedback system built into it where they would get to see the footage?" [CE5].

DISCUSSION

The aim of this study was to explore the issues that might arise from the use of VMS for hand hygiene auditing. In 1969, a study reported the benefits to the use of television videotapes to record and improve practice in the Emergency Department[32]. While the authors advocated the ongoing use of the modality, they highlighted the importance of answering questions

concerning the legal status of the footage, its place as a part of the patient record and the potential for use in litigation, performance appraisal and as a quality improvement tool. Five decades on, similar questions are still being asked and comparable issues remain unresolved.

Patient privacy concerns have long been a major justification for not locating cameras in the patient zone, that is, within the patient's room, cubical or bed area. The issue has been described as creating 'inherent tensions'[33, p. 9), 'special challenges'(J.M.[34, p. 532) and of being 'fraught with problems'[8, p. 291). Suggested solutions, such as low-resolution recording or camera placement to reduce identification, are not appropriate for hand hygiene auditing as they do not allow for the sufficient capture of HCW practices to rate hand hygiene compliance, according to the '5 Moments' framework.[35,36] Studies have reported that patient objections to recording are actually quite rare once information relating to its intent and purpose is provided to the patients.[21]One study found that not only were 81% of patients interested in having their procedures recorded, but further that 63% would be prepared to pay for it.[37] Even though the use of video-based monitoring is increasingly common in both society at large (for example public Closed-Circuit Television (CCTV)) and within health care (such as procedural recordings, falls prevention or for staff safety), it is clear that patient perceptions of video-based auditing need to be further explored given that patient privacy was cited as a barrier by a significant number of participants.

The laws of privacy and consent are jurisdictional to each local health district, network and/or healthcare facility. For example Jacobs, Duncan, Street, and Murray[38] found routine procedural consent was sufficient to cover video recording as it was deemed a standard procedure within their facility. Hu, Peyre, et al.[39]on the other hand described an 'opt out' process rather than consent driven approach. Weinger, Gonzales, Slagle, and Syeed[40] operated under a waiver of consent due to the approach being considered a quality improvement activity. Similarly, Oakley, Stocker, Staubli, and Young[41] were not required to have consent to record pediatric resuscitations as the process was designated an auditing tool. Diller et al. [22]on the other hand obtained formal written consent from 26 participants to perform within zone recording. Australian privacy principles remain unclear, with a sub clause suggesting that the collection of data relevant to or necessary for research, the compilation or analysis of statistics, public health or public safety may constitute a "permitted health situation" (Section 16B) and therefore be exempt from normal consent requirements (Government, 1988).[42] However, the situation is one which would require legal clarification and perhaps even legislative mandate.

Similarly, connected to concerns about electronic monitoring and the uses to which the data could be put, were issues surrounding the security and storage of the recorded footage. Whether a recording is deemed an audit, quality improvement or a part of the patient record impacts on whether there are additional local statutory requirements as to the integrity of data protection, storage and retention.[43]

The term 'Big Brother is watching' has entered the lexicon as an expression of concern about being monitored or watched by higher powers during daily activities.[44] Its use by study participants and its presence in the literature illustrates the concerns they felt about being observed and recorded via video technology and show that such views are common and longstanding in society. Ellingson et al.[45]found that worries about "'Big Brother' implications" (p. 1093) were the most common concerns expressed in focus groups exploring HCW responses to an electronic hand hygiene monitoring system. Numerous authors also report fears that the results derived from electronic hand hygiene compliance monitoring systems could subsequently be used in a pejorative manner, and noted concerns about punishment, dismissal or negative performance review as a result of non-compliance recorded via electronic means.[33,45,46] It has been demonstrated that acceptance of electronic monitoring is notably better in circumstances where only group level data, rather than individual data, was reported to reduce the perception that an individual was being singled out or targeted in any way.[46]Furthermore, as identified by participants this may need to be guaranteed or codified to reassure HCWs.

Anxiety and feelings of discomfort are common responses to being the subject of video recording and the potential for this to impact upon HCW behavior, skills and relationships with patient has been noted.[47] Evidence from the literature would suggest that this is a short-term phenomenon and that staff quickly become habituated to the technology. Hu, Arriaga, et al.[48]comment that "it became apparent that participants forgot about the recording" (p. 9). While Clack et al.[21]note that participants in their study reported that even their awareness of wearing head-mounted cameras "quickly waned" (p. 7) suggesting rapid acclimatization. Clearly steps would need to be taken to reduce HCW anxiety and promote acceptance of VMS in healthcare. This may include the provision of information as to system features including data security measures, password protection, secure non-networked storage, and explicit confidentiality, retention and deletion details. Formal codification of the purpose and usage of the recorded footage, overall governance of the system as well as the manner and nature of the feedback provided at the group and/or individual level has also been recommended.[49,50]

Major concerns and questions regarding the use of video recording of HCW practice in the 1969 study[32] centered around the potential for litigation. While the use of video-based surveillance has increased in healthcare in the form of CCTV, video telemetry, falls or behavioral monitoring, and a wide range of procedural recording, the status of the footage remains unclear in terms of legal discoverability and subsequent potential for personal and organizational liability. In the United States, the literature would suggest that there may be provision for such footage to have protection against discoverability on the basis of being constituted as a quality improvement activity.[50] It is further suggested that footage collected for such purposes does not form a part of the patient record, however where precisely this line is drawn remains unclear.[43] The situation in the Australian context is similarly uncertain. A survey conducted in the US found that deletion of clinical recordings following review was common practice in response to concerns about discoverability but was unable to clarify the impact of this practice in terms of risk reduction.[51] Despite the fears regarding medico-legal risk, evidence would indicate that litigation is an uncommon occurrence and more often than not the video footage provided supportive evidence of good practice in favor of HCWs[52] Interestingly, in terms of public safety, there is a greater acceptance of electronic surveillance in the aviation, maritime transport or offshore oil rigs industries, where 'black box' technology is taken as given.[43] The legal status of footage is another factor that will require clarification at a jurisdictional level as part of any future implementation of such an approach to hand hygiene compliance auditing.

The loss of immediacy of feedback is reported as a concern for VMS auditing. However, several points must be made. Such concerns are in variance to the literature which questions both the efficacy of immediate feedback and the frequency with which it is actually given.[53,54] In addition, the primary intent of the VMS approach is the collection of accurate data, whilst the provision of feedback would remain the remit of the direct observational auditing process. Furthermore, the use of a VMS, as a secondary benefit, provides the potential for detailed contextual reflection on practice at an appropriate time and place through review of the recorded footage.[47]

CONCLUSIONS

Existing studies have supported the technical capacity of hand hygiene compliance according to the WHO '5 Moments for Hand

Hygiene' to be assessed via video-based surveillance.[21,22,55] The use of VMS to improve the transparency, accountability, quality and safety of healthcare in general is an accepted methodology and video-based quality improvement has been advocated as a way to significantly enhance patient safety via not only the collection of more objective and accurate data but also as a way to increase accountably through awareness and self-reflective learning. There are a variety of factors to consider with the use of VMS for hand hygiene compliance auditing. In particular, there is a need to clarify and formally codify privacy, consent and legal liability issues. Further, effort will be required to address HCW anxiety and concerns relating to the potentially punitive consequences of having their practice recorded. Openness, clarity and codification of all aspects of any approach to hand hygiene auditing appear essential factors to address.

Acknowledgment

Thanks to Dr Cecilia Li and Keren Francis for their assistance with proofing and editing.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2021.04.081.

References

1. World Health Organisation. WHO Guidelines on Hand Hygiene in Healthcare. Geneva, Switzerland; 2009. Available at: http://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906_eng.pdf?sequence=1. Accessed May 24, 2021.
2. Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Infect Control Hosp Epidemiol. 2002;23(12 Suppl):S3–40.
3. Grayson ML, Russo PL, Cruickshank M, et al. Outcomes from the first 2 years of the Australian National Hand Hygiene Initiative. Med J Aust. 2011;195:615–619.
4. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. Lancet. 2000;356(9238):1307–1312.
5. Australian Commission on Safety and Quality in Health Care. National Hand Hygiene Initiative Manual. Sydney: Australian Commission on Safety and Quality in Health Care2019.
6. Boyce JM. Hand hygiene compliance monitoring: current perspectives from the USA. J Hosp Infect. 2008;70 Suppl 1(S1):2–7.
7. Diller T, Kelly JW, Steed C, et al. 0016: Electronic hand hygiene monitoring for the WHO 5-moments method. Antimicrobial Resistance and Infection Control. 2013;2(S1).
8. Gould DJ, Drey NS, Creedon S. Routine hand hygiene audit by direct observation: has nemesis arrived? J Hosp Infect. 2011;77:290–293. Privacy Act, (1988).
9. Gould DJ, Creedon S, Jeanes A, Drey NS, Chudleigh J, Moralejo D. Impact of observing hand hygiene in practice and research: a methodological reconsideration. J Hosp Infect. 2017;95:169–174.
10. Pan SC, Tien KL, Hung IC, et al. Compliance of health care workers with hand hygiene practices: independent advantages of overt and covert observers. PLoS One. 2013;8:e53746.
11. Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. American Journal of Infection Control. 2017;45:528–535.
12. Hagel S, Reischke J, Kesselmeier M, et al. Quantifying the hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. Infect Control Hosp Epidemiol. 2015;36:957–962.
13. Australasian College for Infection Prevention and Control. Hand Hygiene Debate in the UK Parliament. 2018. Available at: http://aicalist.org.au/scripts/ws.exe?INDEX&-X=B831249B162AB7AAA5&Y=katmckay68%40gmail.com. Accessed May 24, 2021.
14. Hansard. Infection Prevention and Control. 2018. House of Commons Hansard. Available at: https://hansard.parliament.uk/Commons/2018-05-15/debates/395F355A-2F8A-4175-8408-D9AB8B2AA67C/InfectionPreventionAndControl#-contribution-B2EF1FF6-B01E-4BBB-A51A-3ECA1AF3D0E1. Accessed May 24, 2021.
15. McKay KJ, Shaban RZ, Ferguson P. Hand hygiene compliance monitoring: do video-based technologies offer opportunities for the future? Infect Dis Health. 2020.
16. McLaws ML, Kwok YLA. Hand hygiene compliance rates: fact or fiction? Am J Infect Control. 2018.
17. van de Mortel T, Murgo M. An examination of covert observation and solution audit as tools to measure the success of hand hygiene interventions. Am J Infect Control. 2006;34:95–99.
18. Parsons HM. What happened at Hawthorne? Scienc. 1974;183:922–932.
19. Sahud AG, Bhanot N, Radhakrishnan A, Bajwa R, Manyam H, Post JC. An electronic hand hygiene surveillance device: a pilot study exploring surrogate markers for hand hygiene compliance. Infect Control Hosp Epidemiol. 2010;31:634–639.
20. World Health Organisation. Systematic literature review of automated/electronic systems for hand hygiene monitoring: Preliminary results. 2013. Available at: http://www.who.int/gpsc/5may/automated-hand-hygiene-monitoring.pdf. Accessed May 24, 2021.
21. Clack L, Scotoni M, Wolfensberger A, Sax H. First-person view" of pathogen transmission and hand hygiene - use of a new head-mounted video capture and coding tool. Antimicrob Resist Infect Control. 2017;6:108.
22. Diller T, Kelly JW, Blackhurst D, Steed C, Boeker S, McElveen DC. Estimation of hand hygiene opportunities on an adult medical ward using 24-hour camera surveillance: validation of the HOW2 Benchmark Study. Am J Infect Control. 2014;42:602–607.
23. Hsac B, Rock C, Harris AD, Pineles L, Stein D, Scales T, Program, C. D. C. P. E.. Hand hygiene compliance in the setting of trauma resuscitation. Injury. 2017;48:165–170.
24. Forman J, Creswell JW, Damschroder L, Kowalski CP, Krein SL. Qualitative research methods: key features and insights gained from use in infection prevention research. Am J Infect Control. 2008;36:764–771.
25. Morse JM. Critical analysis of strategies for determining rigor in qualitative inquiry. Qual Health Res. 2015;25:1212–1222.
26. Shenton AK. Strategies for ensuring trustworthiness in qualitative research projects. Education for Information. 2004;22:63–75.
27. Sandelowski M. Qualitative analysis: what it is and how to begin. Res Nurs Health. 1995;18:371–375.
28. Holloway I, Wheeler S. Qualitative Research in Nursing and Healthcare. 3rd ed. Oxford: Wiley Blackwell; 2010.
29. Duncan DF. Content analysis in health education research: an introduction to purposes and methods. Health Education. 2013;20:27–31.
30. Elo S, Kyngas H. The qualitative content analysis process. J Adv Nurs. 2008;62:107–115.
31. Nowell LS, Norris JM, White DE, Moules NJ. Thematic analysis: Striving to Meet the Trustworthiness Criteria. Int J Qual Meth. Available at: https://doi.org/10.1177/1609406917733847. Accessed October 13, 2021.
32. Peltier LF, Geertsma RH, Youmans RL. Television Videotape Recording: an adjunct in teaching emergency medical care. Surgery. 1969;66:233–236.
33. Palmore TN, Henderson DK. Big brother is washing...Video surveillance for hand hygiene adherence, through the lenses of efficacy and privacy. Clin Infect Dis. 2012;54:8–9.
34. Boyce JM, Polgreen PM, Monsalve M, Macinga DR, Arbogast JW. Frequency of Use of Alcohol-Based Hand Rubs by Nurses: A Systematic Review. Infect Control Hosp Epidemiol. 2017;38:189–195.
35. Armellino D, Hussain E, Schilling ME, et al. Using high-technology to enforce low-technology safety measures: the use of third-party remote video auditing and real-time feedback in healthcare. Clin Infect Dis. 2012;54:1–7.
36. Xiao Y, Seagull FJ, Bochicchio GV, et al. Video-based training increases sterile-technique compliance during central venous catheter insertion. Crit Care Med. 2007;35:1302–1306.
37. Rex DK, Hewett DG, Raghavendra M, Chalasani N. The impact of videorecording on the quality of colonoscopy performance: a pilot study. Am J Gastroenterol. 2010;105:2312–2317.
38. Jacobs B, Duncan JR, Street M, Murray D. Audio and video recording system for routine documentation of fluoroscopic procedures. J Vasc Interv Radiol. 2010;21:725–729.
39. Hu YY, Peyre SE, Arriaga AF, et al. Postgame analysis: using video-based coaching for continuous professional development. J Am Coll Surg. 2012;214:115–124.
40. Weinger MB, Gonzales DC, Slagle J, Syeed M. Video capture of clinical care to enhance patient safety. Quality and Safety in Health Care. 2004;13:136–144.
41. Oakley E, Stocker S, Staubli G, Young S. Using video recording to identify management errors in pediatric trauma resuscitation. Pediatrics. 2006;117:658–664.
42. Government A. The Australian Privacy Principles. Australia: Australian Government; 2014. Available at: file:///D:/Documents/PHD/Journal%20Articles/the-australian-privacy-principles%20-%202014.pdf. Accessed May 24, 2021.
43. van Dalen A, Legemaate J, Schlack WS, Legemate DA, Schijven MP. Legal perspectives on black box recording devices in the operating environment. Br J Surg. 2019;106:1433–1441.
44. Ryan J. Observing and normalizing: foucault, discipline, and inequality in schooling: big brother is watching you. The Journal of Educational Thought (JET) / Revue de la Pensee Educative. 1991;25:104–119.
45. Ellingson K, Polgreen PM, Schneider A, et al. Healthcare personnel perceptions of hand hygiene monitoring technology. Infect Control Hosp Epidemiol. 2011;32:1091–1096.
46. Bouk M, Mutterer M, Schore M, Alper P. Use of an Electronic Hand Hygiene Compliance System to Improve Hand Hygiene, reduce MRSA, and Improve Financial Performance. Hobart, Australia: Paper presented at the ACIPC 2015; 2015.
47. Hunukumbure AD, Smith SF, Das S. Holistic feedback approach with video and peer discussion under teacher supervision. BMC Med Educ. 2017;17:179.
48. Hu YY, Arriaga AF, Roth EM, et al. Protecting patients from an unsafe system: the etiology and recovery of intraoperative deviations in care. Ann Surg. 2012;256:203–210.
49. Scott M, Watermeyer J, Wessels TM. Video-recording complex health interactions in a diverse setting: Ethical dilemmas, reflections and recommendations. Dev World Bioeth. 2020;20:16–26.

50. Weinger MB, Gonzales DC, Slagle J, Syeed M. Video capture of clinical care to enhance patient safety. Qual Saf Health Care. 2004;13(2):136–144.
51. den Boer MC, Houtlosser M, van Zanten HA, Foglia EE, Engberts DP, Te Pas AB. Ethical dilemmas of recording and reviewing neonatal resuscitation. Arch Dis Child Fetal Neonatal Ed. 2018;103:F280–F284.
52. O'Donnell CP, Kamlin CO, Davis PG, Morley CJ. Ethical and legal aspects of video recording neonatal resuscitation. Arch Dis Child Fetal Neonatal Ed. 2008;93:F82–F84.
53. Azim S, Juergens C, Hines J, McLaws ML. Introducing automated hand hygiene surveillance to an Australian hospital: mirroring the HOW2 Benchmark Study. Am J Infect Control. 2016;44:772–776.
54. Boscart VM, Fernie GR, Lee JH, Jaglal SB. Using psychological theory to inform methods to optimize the implementation of a hand hygiene intervention. Implementation Science. 2012;7:77.
55. Steed C, Kelly JW, Blackhurst D, et al. Hospital hand hygiene opportunities: where and when (HOW2)? The HOW2 Benchmark Study. Am J Infect Control. 2011;39:19–26.

Appendix C: McKay, K.J., Li, C., Shaban, R.Z., (2022). Using Video-based surveillance for monitoring hand hygiene compliance according to the World Health Organisation (WHO) 5 Moments framework: A pragmatic trial. Infection Control and Hospital Epidemiology. First View, pp. 1-7. doi.org/10.1017/ice.2021.509

Infection Control & Hospital Epidemiology (2022), 1–7
doi:10.1017/ice.2021.509

SHEA

Original Article

Using video-based surveillance for monitoring hand hygiene compliance according to the World Health Organization (WHO) Five Moments framework: A pragmatic trial

Katherine J. McKay RN, IPN, MAdvPrac(Hons1), GCertAdvNurs(CritCare), GCertAdvNurs(ClinNursEd), CertWT&A, CICP-A[1,2], Cecilia Li PhD[2,3] and Ramon Z. Shaban BSc(Med), BN, GradCertInfCon PGDipPH&TM, MEd, MCommHealthPrac(Hons1), PhD, RN, FCENA, FACN, FACIPC, CICP-E[2,3,4]

[1]Faculty of Medicine and Health, Susan Wakil School of Nursing and Midwifery, University of Sydney, Camperdown. New South Wales, Australia, [2]Sydney Institute for Infectious Diseases, University of Sydney, Westmead, New South Wales, Australia, [3]Division of Infectious Diseases and Sexual Health, Department of Infection Prevention and Control, Westmead Hospital and Western Sydney Local Health District, Westmead, New South Wales, Australia and [4]New South Wales Biocontainment Centre, Western Sydney Local Health District and New South Wales Health, Westmead, New South Wales, Australia

Abstract

Objective: To examine the utility of video-based monitoring systems (VMSs) for auditing hand hygiene compliance according to the World Health Organization (WHO) Five Moments.

Design: Pragmatic quasi-experimental observation trial.

Setting: The New South Wales Biocontainment Centre, Westmead, New South Wales, Australia.

Participants: Volunteer healthcare workers (HCWs).

Method: Six high-fidelity simulations were recorded and subsequently assessed for their ability to audit hand hygiene compliance according to the WHO Five Moments for hand hygiene criteria using tools provided by the National Hand Hygiene Initiative (NHHI).

Results: In total, 206 minutes of recorded footage were reviewed in 120 minutes, yielding 111 moments. Overall HCW hand hygiene compliance was 88% according to the WHO Five Moments framework. The cost per moment was $0.91 AUD ($0.66 USD) and the time required per moment was 64 seconds.

Conclusions: Auditing of hand hygiene compliance according to all 5 of the WHO Five Moments from recorded footage is not only possible but provides cost and time savings. In addition, the process may produce output that is less subject to the biases inherent in direct human observational auditing.

(Received 30 September 2021; accepted 2 December 2021)

Hand hygiene is the most pivotal behavior a healthcare worker (HCW) can undertake to prevent the patients in their care from acquiring a healthcare-associated infection (HAI).[1] The relationship between improved hand hygiene compliance and decreasing HAIs has been amply demonstrated.[1–4] The timing of hand hygiene to interrupt the transmission of microorganisms is guided by the World Health Organization (WHO) 'Five Moments for Hand Hygiene,' which also provides a structured framework against which compliance can be measured.[1]

Direct observation has been deemed the gold standard data collection method, and it is mandated in some settings.[1,5] This method has a number of established advantages[6–9]; perhaps the most vaunted is the ability of auditors to provide immediate, contextual, feedback, and education to those they are observing and hence improve practice and, ultimately, hand hygiene compliance.[7] However, direct observation has a number of well-documented disadvantages.[10–14] Many now see the method as a time-consuming and labor-intensive way of collecting small amounts of data with inherent biases that do not reflect typical practice.[15,16] Furthermore, immediate feedback occurs only infrequently and is generally not appreciated by frontline clinicians.[17,18]

Electronic hand hygiene monitoring systems have been proposed as the possible solution to the problems associated with direct observation because they are able to collect large data sets with little human intervention and minimal biases.[19,20] However, some caution that electronic monitoring systems are not a panacea.[21] Chief among the disadvantages of the existing systems is the use of proxy measures of hand hygiene

Author for correspondence: Katherine McKay, E-mail: Kmck4637@uni.sydney.edu.au
Cite this article: McKay KJ, Li C, and Shaban RZ. (2022). Using video-based surveillance for monitoring hand hygiene compliance according to the World Health Organization (WHO) Five Moments framework: A pragmatic trial. Infection Control & Hospital Epidemiology, https://doi.org/10.1017/ice.2021.509

CrossMark

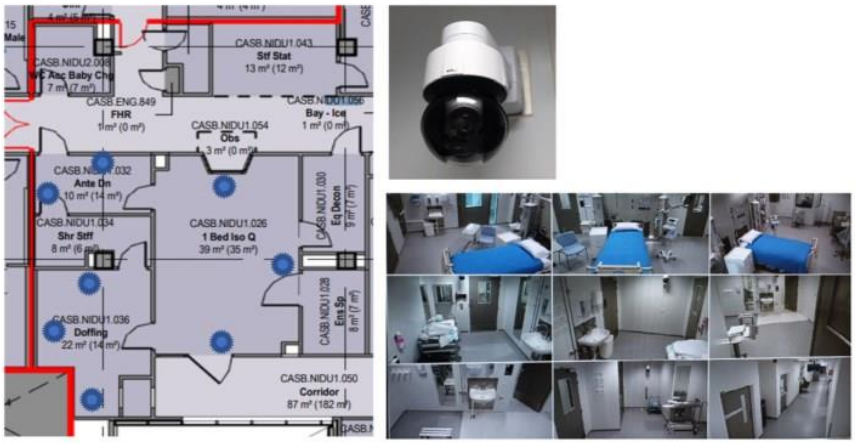


Fig. 1. Camera system in place in the NSW Biocontainment Unit; placemt of cameras, close up image of camera and sample of camera field of view.

compliance rather than the WHO Five Moments framework.[22] These electronic approaches rely on either product consumption or room entry and exit tracking as a surrogate measure of compliance.[14,19,23,24] Although the general presumption is that greater product usage or dispenser activity equates to a higher rate of compliance,[9] some studies have in fact failed to demonstrate a convincing link.[25] Such systems are also often unable to demonstrate the appropriateness of the hand hygiene episode, particularly when it occurs within the patient room or zone. That is, did hand hygiene occur at the optimally correct point in the sequence of the clinical care episode to prevent microbial transmission?[1,21,26,27] Video-based monitoring systems (VMSs) may, however, offer a solution.[22,28] Some studies have suggested that such approaches are technically capable of monitoring all 5 moments[29–31]; however, no system with this primary aim has been demonstrated thus far.

With these parameters in mind, we developed and tested a VMS to audit hand hygiene compliance of healthcare workers according to the WHO Five Moments framework. The key focus was on capturing actual hand hygiene behaviors for analysis according to the WHO Five Moments criteria rather than proxy measures.

Methods

Setting

This pragmatic quasi-experimental observation trial was conducted at the New South Wales Biocontainment Centre, a purpose-built facility for case management and high-level isolation of high-consequence infectious diseases at Westmead Hospital, New South Wales, Australia.

Ethical considerations

Ethics approval for the study was granted by the Human Research Ethics Committee of the Western Sydney Local Health District and Research Governance Committee at Westmead Hospital, NSW, Australia. This study was also considered low risk and adhered to the National Statement on Ethical Conduct in Human Research 2007 (2018 update).[32] There were no variations to the approvals as granted, and no participants withdrew.

Data collection

This study included 2 participant groups. Group 1 comprised 5 volunteer HCWs, 3 registered nurses, and 2 infectious diseases registrars at Westmead Hospital who participated in the scenarios relative to their professional designation. Group 2 comprised 4 volunteer local doctoral students who were simulated patients for the HCW participants. Data collection occurred over 2 consecutive days. We conducted 3 separate simulation scenarios, each of which was undertaken on day 1 and then subsequently repeated on day 2. The HCW participants differed from day 1 to day 2, with only 1 HCW taking part on both days. The scenarios ranged from 22 to 49 minutes in duration, with 100 minutes recorded on day 1 and 106 minutes on day 2.

Scenarios were developed by the research team that included practicing clinicians. The objective of the scenarios was to provide realistic representations of clinical care to be captured by the VMS and to encourage the participants to relate to the actor patients in a realistic way. To promote authentic HCW− patient-actor interactions, the scenarios had high fidelity; they incorporated prosthetics, symptom triggers, and cues, as well as medical equipment and consumables. We provided numerous prompts for the potential performance of hand hygiene and the use of personal protective equipment (PPE) to explore whether compliance with such practices could be audited from recorded footage. Despite the detail in the scenarios, however, they were not heavily scripted, leaving participants to make decisions and manage their patients as they deemed appropriate. Thus, the simulations evolved in unexpected ways.

The simulations were recorded by fixed cameras (Fig. 1) present in the quarantine (Q class) rooms of the New South Wales Biocontainment Centre where the study took place. The Q class suite contains 8 cameras in 3 rooms, 2 in the donning area, 3 in the patient room, and 3 in doffing area, with the feed for each camera being displayed as a multiview arrangement. This system records continuously, with footage stored on a secure server for export and review. Individual images can be enlarged and reviewed

https://doi.org/10.1017/ice.2021.509 Published online by Cambridge University Press

Fig. 2. Single and multi-screen views of footage reacorded during trial in simulation.

using this modality. The system utilizes Milestone XProtect SmartClient_viewer software (Milestone Systems, Lake Oswego, OR) for footage review. This system provides up to 9 camera views at one time, which facilitates tracking from space to space, for example, from donning PPE to patient room and thence to the doffing area (Fig. 2). The system also allowed full-screen focus on a single camera view as well as the ability to zoom, freeze, fast forward, and rewind.

Data analysis

The recorded footage was reviewed by the researcher McKay, who is a current Gold Standard Auditor using the WHO Five Moments definitions of what constituted a hand hygiene moment and utilizing the tools developed by the National Hand Hygiene Initiative (NHHI) for direct observational auditing (Supplementary Material online).

The metrics included the compliance with hand hygiene practice according to moment and healthcare worker designation and the total time taken to audit each scenario. In addition, auditor reflections regarding the process of auditing from the recorded footage were also noted.

Results

In total, 206 minutes (3.4 hours) of footage were recorded over the 2-day trial. This footage was recorded by each of the 8 fixed-camera feeds, which could be viewed either collectively as an 8-view split screen or individually as a full-screen view.

Auditing of the 6 simulations was undertaken by researcher McKay and was verified by the other researchers on the study team (Fig. 3). Viewing the 8 camera feeds simultaneously cast to a large screen was determined to be the easiest method. This method allowed participants to be tracked from camera to camera as they

https://doi.org/10.1017/ice.2021.509 Published online by Cambridge University Press

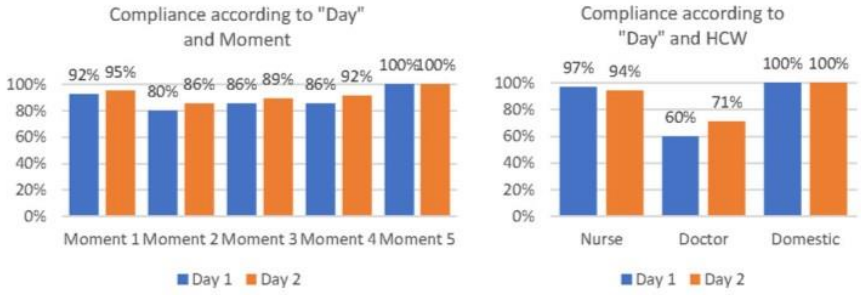


Fig. 3. Hand hygiene compliance according to day, moment and HCW as audited from recorded footage.

Table 1. Results of Auditing From Footage: Total Time, Auditing Time and Compliance Rate

Day/Scenario	Duration of Simulation	Time Taken to Complete Auditing from Footage	Time Saving	Total No. of Moments	No. of Correct Moments	Compliance Rate, %
Day 1: Simulation 1[a]	29 min	13 min	16 min	8	7	88
Day 1: Simulation 2[b]	49 min	21.5 min	27.5 min	24	23	96
Day 1: Simulation 3[c]	22 min	15 min	7 min	10	7	70
Day 2: Simulation 1[a]	36 min	24 min	12 min	17	14	82
Day 2: Simulation 2[b]	43 min	29 min	14 min	41	38	93
Day 2: Simulation 3[c]	27 min	17.5 min	9.5 min	11	9	82
Overall totals	206 min	120 min	86 min	111	98	88

[a]Simulation 1: Basic physical assessment and history taking in a patient with a fever.
[b]Simulation 2: Management of a returned traveller with an infected leg wound.
[c]Simulation 3: Care of a patient with suspected tuberculosis.

Table 2. Results of Audit of Recorded Footage, According to Day and Moment According to the WHO Five Moments Criteria

	Day 1			Day 2		
Moment	Total Moments	Correct Moments	Compliance Rate, %	Total Moments	Correct Moments	Compliance Rate, %
Moment 1	13	12	92	20	19	95
Moment 2	5	4	80	16	12	75
Moment 3	7	6	86	19	17	89
Moment 4	14	12	86	12	11	92
Moment 5	3	3	100	2	2	100

moved from room to room, and it captured hand hygiene opportunities and/or moments that occurred outside the patient zone in the donning and doffing areas. The footage was viewed at different playback speeds, paused, or rewound as needed. The system also had the capacity to enhance and zoom into individual views so that practice could be examined more closely.

The recorded simulation footage on day 1 totaled 100 minutes, and auditing time from the footage required 49.5 minutes (Table 1) due to the ability to fast forward the recording. In total, 42 moments were collected, with a compliance rate of 88% overall (range, 70%–96% depending on scenario) (Table 2). However, 15 episodes of unnecessary hand hygiene were also observed. Compared to the total duration of the scenario, this method represented a savings of >50 minutes in auditing time with a collection rate of ~ 70 seconds per moment. In terms of cost based on the auditor wage of $50 AUD ($36 USD) per hour, the overall cost of auditing from VMS footage was $41.25 AUD ($30 USD) or ~ $0.98 AUD ($0.71 USD) per moment.

Footage recorded on day 2 was 106 minutes in duration. Auditing of the scenarios from the footage took 69.5 minutes, for a collection rate of 60 seconds per moment. In total, 69 moments were collected; they achieved a compliance rate of 88% (range, 82%–93%) (Table 2). Notably, 23 episodes of unnecessary hand hygiene occurred, including several episodes of the application of hand rub to gloves. The overall auditing cost for the scenarios was ~ $58 AUD ($42 USD) or ~ $0.84 AUD ($0.60 USD) per moment.

The footage analysis provides a breakdown according to moment and HCW classification, which follows current NHHI reporting requirements. These results clearly illustrate the capacity

https://doi.org/10.1017/ice.2021.509 Published online by Cambridge University Press

of a VMS to collect data consistent with the WHO Five Moments criteria and in a format suitable for submission to the NHHI.

Discussion

Existing research has suggested the utility of electronic systems for the collection of hand hygiene compliance data. However, because this research is largely limited to the use of proxy measures such as product consumption and/or room entry and exit, these systems are of concern.[21,33] Stewardson and Pittet[34] warned of the importance of monitoring behaviors and actions that actually "correspond conceptually with patient safety" (p. 1030). They noted that although monitoring and promoting hand hygiene prior to door opening may be simple, convenient, and indeed technologically possible, it may not be either useful or desirable in terms of best practice for patient safety. Thus, rather than defining compliance as adherence to practices which best decrease the risk of microbial transmission, there could be a risk of changing the definition of what constitutes hand hygiene compliance to fit with the monitoring capacity of the technology.

Although this study utilized a trial in simulation with volunteer participants, rather than actual clinical care episodes to record footage, this does not negate the validity of the results. The high-fidelity nature of the scenarios provided a realistic simulacrum of HCW–patient interaction and demonstrates the utility of using video monitoring to capture and assess hand hygiene compliance according to the 5 moments framework. The use of the multiple camera array meant that the entire hand hygiene journey of the participant HCWs could be captured. Subsequent review of the footage demonstrated the ability to clearly distinguish all 5 of the WHO Five Moments as they occurred and according to the WHO Five Moments criteria rather than by proxy measures. Proxy measures have been reported in the literature, notably the research using room-entry and -exit measures via video camera by Armellino et al[35] and research using patient-zone entry coupled with dispenser activation by Al Salman et al.[36]

The time, and consequently financial, savings demonstrated in our results confer additional advantage to the approach. We determined that auditing from the recorded footage for both days represented a saving of 86 minutes. When compared to time taken if direct observational auditing was employed, this equated to a saving of 84 seconds per moment. Furthermore, this calculation assumed that a human auditor would be able to capture all moments with the same certainty as was able to be achieved from the footage. We suspect that a higher yield of moments was achieved from the footage due to the capacity to freeze, slow, and rewind the footage, in addition to the lack of distraction during auditing, which took place away from the clinical setting. Auditing using recorded footage would cost $99.17 AUD ($ 71.59 USD) or $0.89 AUD ($0.64 USD) per moment for the 6 simulation scenarios, whereas direct observational auditing would have cost $171.67 AUD ($123.92 USD) or $1.55 AUD ($1.12 USD) per moment. These figures are lower than the cost per moment of $2.24 AUD ($1.62 USD) suggested by Azim and McLaws.[37] With data from the NHHI in Australia showing the collection of >1.8 million moments per year,[38] the potential financial benefits could be considerable. The cost and time savings of auditing practice from footage has been noted in the literature. Hu et al[39] estimated a 50%–80% time savings in data review due to the ability to fast-forward footage when appropriate. This report supports the enhanced efficiency of video-monitoring technologies. Recorded footage may also be reviewed at a more convenient time compared to direct observation data gathering, which typically occurs during the day shift on weekdays. The rationale for selecting this time is that the clinical areas are the busiest and larger amounts of hand hygiene will be being performed; hence, data gathering is most efficient. However, this practice may not only foster selection bias but may create conflict for local, ward-based auditors with dual clinical and auditing roles.[8,23,40]

Another useful aspect of collecting data using video monitoring technology is the potential to collect less biased results. The practices of all HCWs who come within the view of the camera lens are captured, hence eliminating or at the very least significantly reducing selection bias. In addition, observer bias may be reduced, interauditor reliability issues may be solved by auditing from footage because multiple auditors can review the same episode and compare results.[41] Footage can be manipulated to ensure certainty (ie, by rewinding, slowing motion, and freezing frames) and to facilitate discussion, review, and clarification of difficult or ambiguous situations. In addition, observation bias or the Hawthorne effect is reduced by camera versus direct observation; a camera creates less behavioral change than a human observer. Several studies involving video recording of participants in clinical or simulated clinical contexts have shown the reduction or elimination of the Hawthorne effect in the presence of cameras.[30,39,42] More accurate hand hygiene data would allow the identification of practice deficits and open the possibilities of targeted change strategies to improve patient safety and quality of care.

The results of this study demonstrate that video-based auditing of hand hygiene is indeed technically possible. These findings suggest that it may be achieved in a more efficient manner than via traditional human direct observation, a suggestion which was raised by participants in preparatory work.[43] In addition, resultant data may represent a truer reflection of practice than data produced by direct observation. These results are significantly less biased, they are able to be collected without intrusion, and they have enhanced credibility due to inherent accuracy and completeness of the record. This approach allows for what Broyles et al[44] have described as nuanced levels of analysis.

The COVID-19 global pandemic has accelerated the development, use and acceptability of various video-based "telehealth" modalities.[45,46] Vilendrer et al[45] suggest that the optimal set up would be to have the facility for such approaches in every patient room as a way of optimizing communication for patients requiring isolation precautions and preventing pathogen transmission. They go on to suggest the utility of using the technology for other purposes such as "virtual sitters," the facilitation of visitor interaction and the enhancement of clinician convenience and efficiency.[45] Furthermore, developments in the use of cameras for fall prevention and elder abuse (so called "granny cams") also have additional possibilities in aged-care settings.[41,47,48] Video monitoring within the patient zone has the potential to enhance patient safety and quality of care through the accurate identification and subsequent remediation of practice shortfalls.

This study had several limitations. Auditing was conducted by a single member of the research team who is a validated Gold Standard Auditor under the NHHI in Australia. Although this could represent a limitation of the study, the practice is consistent with direct observational auditing under the NHHI framework where results are collected and submitted based on the interpretation of a single individual.

https://doi.org/10.1017/ice.2021.509 Published online by Cambridge University Press

In conclusion, our earlier works explored the question of the methodological and technical considerations for video-based auditing of hand hygiene practice[43,49] and established the basis of the current study. We have demonstrated the technical capacity of a multicamera VMS to record footage of clinical practice via high-fidelity simulation which can subsequently be audited for hand hygiene compliance against the WHO Five Moments criteria rather than proxy measures such as entry and exit.

Furthermore, utilizing this approach may produce output data that are more representative of true, unbiased hand hygiene compliance behavior and provide time and cost savings as well as convenience for auditors. This research is intended as a launching point for the development and refinement of camera systems within the patient zone with which to audit hand hygiene as well as other infection prevention and control behaviors. Another question that needs to be addressed, notwithstanding the technical capacity to record and subsequently audit hand hygiene behaviors, is this: What is the acceptability of the practice to HCW and patients? This factor could be an obstacle despite the benefits of this approach.

Acknowledgments. We thank the volunteers who participated in our study. We acknowledge Dr Cristina Sotomayor-Castillo, Dr Shizar Nahidi and Dr Keren Kaufman-Francis for their support and assistance with this study.

Financial support. This study was supported by a University of Sydney PhD candidate stipend, and the 2020 Seed Grant Fund from the Sydney Institute for Infectious Diseases at the University of Sydney.

Conflicts of interest. All authors report no conflicts of interest relevant to this article.

References

1. WHO guidelines on hand hygiene in healthcare. World Health Organization website. https://www.who.int/publications-detail-redirect/9789241597906. Published 2009. Accessed February 24, 2022.
2. Boyce JM, Pittet D. Guideline for hand hygiene in healthcare settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA hand hygiene task force. Infect Control Hosp Epidemiol 2002;23 suppl 12:S3–S40.
3. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. Lancet 2000;356:1307–1312.
4. Grayson ML, Russo PL, Cruickshank M, et al. Outcomes from the first 2 years of the Australian National Hand Hygiene Initiative. Med J Aust 2011;195:615–619.
5. National Hand Hygiene Initiative Manual. Australian Commission on Safety and Quality in Health Care website. https://www.safetyandquality.gov.au/our-work/infection-prevention-and-control/national-hand-hygiene-initiative-nhhi/national-hand-hygiene-initiative-manual. Published 2019. Accessed February 24, 2022.
6. Gould DJ, Creedon S, Jeanes A, Drey NS, Chudleigh J, Moralejo D. Impact of observing hand hygiene in practice and research: a methodological reconsideration. J Hosp Infect 2017;95:169–174.
7. Pan SC, Tien KL, Hung IC, et al. Compliance of healthcare workers with hand hygiene practices: independent advantages of overt and covert observers. PLoS One 2013;8:e53746.
8. Haas JP, Larson EL. Measurement of compliance with hand hygiene. J Hosp Infect 2007;66:6–14.
9. Gould DJ, Drey NS, Creedon S. Routine hand hygiene audit by direct observation: has nemesis arrived? J Hosp Infect 2011;77: 290–293.
10. Fisher DA, Seetoh T, May-Lin HO, et al. Automated measures of hand hygiene compliance among healthcare workers using ultrasound: validation and a randomized controlled trial. Infect Control Hosp Epidemiol 2013;34:919–928.
11. Cantrel S. Electronic hand-hygiene systems take compliance to the next level. In: Healthcare Purchasing News. Sarasota, FL: Endeavor Business Media; 2016:24–29.
12. Larson EL. Monitoring hand hygiene: meaningless, harmful, or helpful? Am J Infect Control 2013;41 suppl 5:S42–S45.
13. Pong S, Holliday P, Fernie G. Secondary measures of hand hygiene performance in health care available with continuous electronic monitoring of individuals. Am J Infect Control 2019;47:38–44.
14. McLaws ML, Kwok YLA. Hand hygiene compliance rates: fact or fiction? Am J Infect Control 2018;46:876–880.
15. Hagel S, Reischke J, Kesselmeier M, et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. Infect Control Hosp Epidemiol 2015;36:957–962.
16. Boyce JM, Cooper T, Dolan MJ. Evaluation of an electronic device for real-time measurement of alcohol-based hand rub use. Infect Control Hosp Epidemiol 2009;30:1090–1095.
17. Boscart VM, Fernie GR, Lee JH, Jaglal SB. Using psychological theory to inform methods to optimize the implementation of a hand hygiene intervention. Implement Sci 2012;7:77.
18. Azim S, Juergens C, Hines J, McLaws ML. Introducing automated hand hygiene surveillance to an Australian hospital: mirroring the HOW2 benchmark study. Am J Infect Control 2016;44:772–776.
19. Srigley JA, Lightfoot D, Fernie G, Gardam M, Muller MP. Hand hygiene monitoring technology: protocol for a systematic review. Syst Rev 2013;2:101.
20. Ellingson K, Polgreen PM, Schneider A, et al. Healthcare personnel perceptions of hand hygiene monitoring technology. Infect Control Hosp Epidemiol 2011;32:1091–1096.
21. Srigley JA, Furness CD, Baker GR, Gardam M. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. BMJ Qual Saf 2014;23:974–980.
22. Systematic literature review of automated/electronic systems for hand hygiene monitoring: preliminary results. World Health Organization website. http://www.who.int/gpsc/5may/automated-hand-hygiene-monitoring.pdf. Published 2013. Accessed December 6, 2018.
23. Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Control 2017;45:528–535.
24. Pires D, Pittet D. Hand hygiene electronic monitoring: are we there yet? Am J Infect Control 2017;45:464–465.
25. Cohen B, Murray M, Jia H, et al. Is hand hygiene frequency associated with the onset of outbreaks in pediatric long-term care? Am J Infect Control 2016;44:1492–1494.
26. Gould DJ, Chudleigh J, Drey NS, Moralejo D. Measuring handwashing performance in health service audits and research studies. J Hosp Infect 2007;66:109–115.
27. Storey SJ, FitzGerald G, Moore G, et al. Effect of a contact monitoring system with immediate visual feedback on hand hygiene compliance. J Hosp Infect 2014;88:84–88.
28. Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Control 2017;45:528–535.
29. Haac B, Rock C, Harris AD, et al. Hand hygiene compliance in the setting of trauma resuscitation. Injury 2017;48:165–170.
30. Clack L, Scotoni M, Wolfensberger A, Sax H. "First-person view" of pathogen transmission and hand hygiene—use of a new head-mounted video capture and coding tool. Antimicrob Resist Infect Control 2017;6:108.
31. Diller T, Kelly JW, Blackhurst D, Steed C, Boeker S, McElveen DC. Estimation of hand hygiene opportunities on an adult medical ward using 24-hour camera surveillance: validation of the HOW2 Benchmark Study. Am J Infect Control 2014;42:602–607.
32. National statement on ethical conduct in human research, 2007. National Health and Medical Research Council website. https://www.nhmrc.gov.au/about-us/publications/national-statement-ethical-conduct-human-research-2007-updated-2018. Published 2007. Updated 2018. Accessed February 24, 2021.

https://doi.org/10.1017/ice.2021.509 Published online by Cambridge University Press

33. Sahud AG, Bhanot N, Narasimhan S, Malka ES. Feasibility and effectiveness of an electronic hand hygiene feedback device targeted to improve rates of hand hygiene. J Hosp Infect 2012;82:271–273.
34. Stewardson A, Pittet D. Quicker, easier, and cheaper? The promise of automated hand hygiene monitoring. Infect Control Hosp Epidemiol 2011;32:1029–1031.
35. Armellino D, Hussain E, Schilling ME, et al. Using high-technology to enforce low-technology safety measures: the use of third-party remote video auditing and real-time feedback in healthcare. Clin Infect Dis 2012;54:1–7.
36. Al Salman JM, Hani S, de Marcellis-Warin N, Isa F. Effectiveness of an electronic hand hygiene monitoring system on healthcare workers' compliance to guidelines. J Infect Public Health 2015;8:117–126.
37. Azim S, McLaws ML. Doctor, do you have a moment? National Hand Hygiene Initiative compliance in Australian hospitals. Med J Aust 2014;200:534–537.
38. National Hand Hygiene Initiative website. https://nhhi.safetyandquality.gov.au/en_AU/NHHI/dashboard. Published 2020. Accessed February 24, 2022.
39. Hu YY, Peyre SE, Arriaga AF, et al. Postgame analysis: using video-based coaching for continuous professional development. J Am Coll Surg 2012;214:115–124.
40. Daniels TL. Reconsidering hand hygiene monitoring. J Infect Dis 2012;206:1488–1490.
41. Woolrych R, Zecevic A, Sixsmith A, et al. Using video capture to investigate the causes of falls in long-term care. Gerontologist 2015;55:483–494.
42. Filho MA, Marra AR, Magnus TP, et al. Comparison of human and electronic observation for the measurement of compliance with hand hygiene. Am J Infect Control 2014;42:1188–1192.
43. McKay KJ, Ferguson PE, Shaban RZ. Methodological and technical considerations for video-based auditing of hand hygiene compliance in clinical practice: an exploratory study. Am J Infect Control 2021;49:1384–1391.
44. Broyles LM, Tate JA, Happ MB. Videorecording in clinical research: mapping the ethical terrain. Nurs Res 2008;57:59–63.
45. Vilendrer S, Patel B, Chadwick W, et al. Rapid deployment of inpatient telemedicine in response to COVID-19 across three health systems. J Am Med Inform Assoc 2020;27:1102–1109.
46. Ostrowsky BE, Weil LM, Olaisen RH, et al. Real-time virtual infection prevention and control assessments in skilled nursing homes, New York, March 2020—a pilot project. Infect Control Hosp Epidemiol 2021. doi: 10.1017/ice.2021.100.
47. Ostervang C, Vestergaard LV, Dieperink KB, Danbjørg DB. Patient rounds with video-consulted relatives: qualitative study on possibilities and barriers from the perspective of healthcare providers. J Med Internet Res 2019;21:e12584.
48. Berridge C, Halpern J, Levy K. Cameras on beds: the ethics of surveillance in nursing home rooms. AJOB Empir Bioeth 2019;10:55–62.
49. McKay KJ, Shaban RZ, Ferguson P. Hand hygiene compliance monitoring: do video-based technologies offer opportunities for the future? Infect Dis Health 2020;25:92–100.

https://doi.org/10.1017/ice.2021.509 Published online by Cambridge University Press

Appendix D: McKay, K.J., Li, C., Shaban, R.Z., Ferguson, P.E., Sotomayor-Castillo, C., Wyer, M. (2022). Healthcare workers' experiences of video-based monitoring of hand hygiene behaviours. American journal of Infection control. In press, corrected proof available online 22 March 2022. doi.org/10.1016/j. ajic.2022.03.010.

ARTICLE IN PRESS

American Journal of Infection Control 000 (2022) 1–6

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Health care workers' experiences of video-based monitoring of hand hygiene behaviors: a qualitative study

Katherine J. McKay RN, IPN, MAdvPrac(Hons1), GCertAdvNurs(CritCare), GCertAdvNurs(ClinNursEd) [a,b,*], Cecilia Li PhD [a,b], Cristina Sotomayor-Castillo PhD [a,b], Patricia E. Ferguson PhD [b,c,d], Mary Wyer PhD [a,b,d], Ramon Z. Shaban PhD [a,b,d,e]

[a] Faculty of Medicine and Health, Susan Wakil School of Nursing and Midwifery, University of Sydney, Camperdown, NSW, Australia
[b] Sydney Institute for Infectious Diseases, University of Sydney, Camperdown, NSW, Australia
[c] Centre for Infectious Diseases and Microbiology, Westmead Hospital, Western Sydney Local Health District, Westmead, NSW, Australia
[d] New South Wales Biocontainment Centre, Western Sydney Local Health District and New South Wales Health, NSW, Australia
[e] Department of Infection Prevention and Control, Division of Infectious Diseases and Sexual Health, Westmead Hospital and Western Sydney Local Health District, Westmead, NSW, Australia

Key Words:
Handhygiene
Compliance
Direct observation Auditing
Video surveillance
Acceptability

A B S T R A C T

Background: Hand hygiene is key to preventing health care-associated infections. Human observation is the gold standard for measuring compliance, but its utility is increasingly being questioned with calls for the use of video monitoring approaches. The utility of video-based systems to measure compliance according to the WHO 5 moments is largely unexamined, as is its acceptability amongst health care workers (HCW) and patients. This study examined HCW acceptability of video monitoring for hand hygiene auditing.
Methods: Following trial of a video monitoring system (reported elsewhere), 5 participating HCW attended 2 in-depth group interviews where they reviewed the footage and explored responses to the approach. Transcripts were analyzed using thematic analysis.
Results: Four themes were identified: 1) Fears; 2) Concerns for patients; 3) Changes to feedback; and 4) Behavioral responses to the cameras. HCWs expressed fears of punitive consequences, data security, and confidentiality. For patients, HCWs raised issues regarding invasion of privacy, ethics, and consent. HCWs suggested that video systems may result in less immediate feedback but also identified potential to use the footage for feedback. They also suggested that the Hawthorne Effect was less potent with video systems than human observation.
Conclusions: The acceptability of video monitoring systems for hand hygiene compliance is complex and has the potential to complicate practical implementation. Additionally, exploration of the acceptability to patients is warranted.
Checklist: COREQ

* Address correspondence to Katherine McKay, RN IPN MAdvPrac(Hons1), GCertAdvNurs(CritCare), GCertAdvNurs(ClinNursEd), Westmead Hospital, Office 2033, Research and Education Network Building, Darcy Road, Westmead NSW 2145 Australia.
E-mail address: Kmck4637@uni.sydney.edu.au (K.J. McKay).

Author contribution: RZS established the study concept and the warrant for the manuscript and all authors were involved in drafting, revising and had critical input into the paper.
Conflict of interest: None to report.
Funding: This study was supported by a University of Sydney PhD candidate stipend, and a 2020 Seed Funding Grant from the Sydney Institute for Infectious Disease at the University of Sydney.

BACKGROUND

The importance of hand hygiene in preventing healthcare-associated infections (HAI) is well established, with practice guided by the World Health Organization (WHO) "5 Moments for Hand Hygiene" framework.[1-3] This framework provides direction as to when hand hygiene should occur and methodology for assessing compliance.[1] Direct observation is currently the recommended data collection method whereby human auditors are present in the clinical setting to assess health care worker (HCW) practice according to the 5

https://doi.org/10.1016/j.ajic.2022.03.010

Moment criteria.[1,4] While direct observation as a data collection technique has advantages, it is increasingly being questioned[5-10] given it is resource intensive, yielding small, nonrepresentative samples subject to the Hawthorne effect and other biases.[5,11,12]

An assortment of electronic monitoring systems have been proffered as alternatives to direct observation on the basis that they can collect large, bias free, data sets without the need for human intervention.[13-15] Initially responses to these systems were enthusiastic, however, the limitations have also been recognized.[8,16] The chief concern with these approaches is the reliance on proxy measures of compliance, such as product consumption or room entry/exit, rather than assessment of actual hand hygiene according to the WHO 5 Moments framework.[8,14,16-18] While some research suggests high rates of product use correlates with higher hand hygiene compliance,[19,20] this is not universally the case.[21] In addition, the use of proxy measures means that it is not always possible to establish the appropriateness of the hand hygiene episode in relation to patient contact. This in turn means that hand hygiene may not have occurred at the optimal time to prevent microbial transmission.[1,15,22,23]

Video-based monitoring systems have been proposed as a possible solution yet many still rely on proxy measure of room entry and exit.[18,24-26] A growing body of literature suggests that video-based approaches are technically capable of monitoring all 5 moments and should be pursued.[27–29]

We recently conducted a study to examine the use of a video monitoring system to capture and audit hand hygiene practice according to the 5 Moments (under review).[30] While this trial demonstrated the technical ability to measure compliance according to the WHO criteria, our earlier work had anticipated potential concerns as to the acceptability of using a video monitoring system to capture HCW-patient interactions.[9,31,32] Our previous work identified themes relating to predicted concerns about 'big brother' style monitoring, potential punitive uses of recorded footage, impacts upon patient privacy, data security, medico-legal risks, and a lack of immediate feedback. In this paper, we report the acceptability of using video monitoring for hand hygiene auditing from the perspective of participating HCWs.

METHODS

Design

A qualitative study with a pragmatic naturalistic observational perspective.

Setting

The study was conducted at the New South Wales Biocontainment Center, a purpose-built facility for management of high consequence infectious diseases at Westmead Hospital, New South Wales, Australia, in February 2021.

Ethical considerations

Ethics approval for the study was granted by the Human Research Ethics Committee of the Western Sydney Local Health District at Westmead Hospital, Australia. This study was also considered low risk and adhered to the National Statement on Ethical Conduct in Human Research 2007 (2018 update).[33] Written consent was obtained from all participants. There were no variations to the approvals as granted, and no participants withdrew.

Data collection

Participants for this study were invited to voluntarily participate on the basis of their clinical skill base, their employment at the trial site and their willingness and interest. Recruitment was via internal hospital communications and resulted in the participation of 5 volunteer HCWs; 3 registered nurses and 2 registrars from the Infectious Diseases Unit at Westmead Hospital who engaged in high fidelity simulation scenarios relative to their professional designation. The simulations featured volunteer 'actor patients' with real props such as medical equipment, consumables, mock results, body fluids, and artificial wounds in an actual clinical setting. The aim of the study was to establish the utility of a video monitoring system for auditing hand hygiene compliance according to the 5 Moments criteria. The process and outcome of the trial has been described elsewhere (currently under review at time of writing)[30] and the technical capacity to audit hand hygiene compliance according to the WHO 5 moments using the approach was established.

Immediately following the scenarios all HCW participants took part in post simulation, group interviews which also included review of the recorded footage. The aim was to allow for reflexive debriefing and to explore their responses to the recording process. This also allowed the examination of key ideas surrounding acceptability which had emerged from earlier work and the broader literature.[9, 10] Semistructured questions were used to guide the discussion. The sessions were audio recorded, resulting in almost 2 hours of data which was then transcribed verbatim. De-identified transcripts were returned to participants for member checking upon request.

Data analysis

The data from interviews underwent content and thematic analysis which is a common approach in nursing and health care research.[34,35] The semistructured questions formed a guide for the open coding system and the generation of descriptive categories in turn helped to ensure the credibility of the data.[34,36,37] Prolonged engagement with the data allowed initially broad themes to be further clarified and condensed.[36,38] The analysis of the resultant thematic categories enabled the illumination of participants perceptions of the experience of participation in the video recording of hand hygiene behaviors.

RESULTS

Four themes emerged from the analysis of the participants' reflection upon their experience as subjects of a video monitoring system to audit hand hygiene practice; (1) fears, (2) concerns for patients, (3) changes to feedback, and (4) behavioral responses to the cameras.

Fears

HCWs expressed 'fears' as being the negative reactions to, or concerns with the use of a video monitoring system to record their practice. Some of this fear was associated with receiving negative feedback, although they acknowledged the importance of feedback to improve practice:

> "I'm ok.. like me personally as a nurse .. I feel ok with it because I just see it as a way to . . . um.. be better . . ." [NURSE2]

While they reported that they intellectually understood the importance of quality improvement in health care practice they also expressed a fear of feedback as criticism, akin to being 'told off' or "getting into trouble".

> "Yeah. . . I um. . . I think it's always nervous to know that you're being watched .. but I think it's an important part of .. um . . . improving processes and systems" [REGISTRAR2].

Another significant 'fear' was the potential for the footage to be used in a punitive manner, with participants expressing concern that the identification of incorrect practice could result in a punitive response

"..people are not then using it . . . you know the powers that be .. on your.. [record] you know, particularly a bad manger or something deciding that they were going to use it for targeting people.. or stuff like that [NURSE1]

For some the line between appropriate, useful and meaningful feedback and 'unusual scrutiny' was one that needed to be clearly drawn:

"Say for instance if you were auditing some people and not others would this count as unusual scrutiny. . .. say if your job. . .. if your contract was up for renegotiation or something like that?" [REGISTRAR1].

Participants also expressed concerns about staff feeling "stressed and hammered", potential "secret police" behavior in terms of data collection and the need to:

". . .. be careful how you approach it in terms of tailoring it so that you don't .. have a distressed junior doctor being more stressed . . . because they're already really really stressed and a whole bunch of them already kill themselves every year so yeah. . . don't 'stacks on' with that" [REGISTRAR1].

To resolve these fears, participants expressed the need to create a 'safe place' and to ensure that auditors were well trained in the provision of feedback so that HCWs did not feel awkward or upset, and that feedback was provided in a 'non-punitive' manner.

There was also a clear view that it was important to follow-up observed poor practice and that any behaviors that fell under mandatory reporting or criminal criteria should be referred to appropriate authorities. Examples included assault, theft or inappropriate medication administration. On the other hand, it was not considered essential to report every missed hand hygiene moment. The gray area was in between these 2 extremes. It was suggested that a predefined list of behaviors or omissions which could impact on patient safety and which participants referred to as 'things', would trigger feedback to the HCW concerned;

"I guess maybe.. the auditors knowing .. what you. . . like a .. a list of things that they can have someone that they can go to too to say what is. . .. I mean I don't know. . . how do you work that out . . ." [NURSE1].

"You'd probably have to have a predefined set of what's really dangerous I guess. . .." [REGISTRAR1].

". . .keep adding to it as you see more things (Laughs)" [NURSE1]

These comments suggest that participants were unable to comprehensively define the kinds of activities which would trigger feedback from auditor to HCW. Some were able to offer suggestions such as 'failing to swab a central line hub before injecting' or 'cannulating from the bed', however, others were less certain, not only about what should be reported back to clinicians but what should be audited in the first place. Again, this seemed to reflect a concern about 'getting into trouble' or other negative consequences as a result of any detected non-compliance or poor practice. The confusion, concern and overall uncertainty are clearly evident in the response from the following participant:

"I think .. to an extent if there is that degree of monitoring and that degree of trying to pick up on things . . . I mean of course we should improve the practices of HCWs but I think.. um.. you know.... I feel. . . like I do .. I think there's .. I don't .. I don't know the ethics of that .. I'm not comfortable. . . I'm not entirely comfortable with having everything that's put on camera auditable . . . Unless .. I guess . . . it's done in an appropriate manner." [REGISTRAR2].

The safety and security of any recorded footage was another area of concern and appeared to be related to fears that "others" may see the recordings and form negative opinions of the HCW's in question as a consequence. Hence participants were concerned that only 'certain people' would have access to the footage. Specifically, important to participants was that this did NOT include managers which was felt could otherwise lead to negative consequences, including formal reprimand or loss of good opinion.

"I think it would have to be a select number of people who could see [the footage] .. and I don't think that your manager should be one of those people who could have access . . .. I think it should only be the people who are auditing or who have that role of auditing" [REGISTRAR2].

In addition, it was made clear that results of any practice auditing be must be reported in a way so as to protect the individual HCW.

"You don't want your colleagues talking about you like . . .'oh that person' you know – 'cause you don't half the ward dissecting a video' .. going 'Oh my God. . . bloody Jane'" [NURSE2].

It was also seen as important that any detected issues be addressed directly with the individual HCW as a primary response. This was in order to both maintain confidentiality and avoid concerns about punitive uses of the data. Further, it was essential that this one-to-one feedback be given in a safe and supportive manner.

"It comes to you first as a first line, as the first line of being told is the person who did it and they get the opportunity to .. a right of reply" [NURSE1]

"I would appreciate to be pulled aside and coached through that . . ." [NURSE2]

". . .but also given a chance to say why you did it . . . and whether you actually .. like something went wrong or actually "I had no idea that I did that" or you know any of that stuff." [NURSE1]

The only exception to this approach was, for the sake of patient safety and quality of care, any instance when the HCW refused to engage in remedial action as Registrar1 explained;

".. if you've got like a junior Dr that does something wrong and they. . . don't engage with the process or something .. obviously .. you'd need to feedback to their supervisor . . . so that there could be further involvement with that"[REGISTRAR1].

There was also a concern that footage should not be permanently retained but should rather be 'destroyed' following auditing. The use of the term destroyed rather than erased or deleted suggests the

strength of this imperative which was seen to protect HCWs' confidentiality and prevent any potential punitive uses.

Concerns regarding a fear of litigation were not strongly represented, although participants did speak of their reservations relating to the 'legal and logistic stuff' and the question was asked;

> "Who then has rights to that data ... say if you've got an allegation of improper medical or nursing behaviour ... or if there's an RCA (Root Cause Analysis) or something like that ... who has access to that film?" [REGISTRAR1].

That this was raised as a response theme to the use of video monitoring technology would indicate that the legal status and discoverability of recorded footage is an issue that would need to be resolved as part of any implementation process.

Concerns for patients

Participants expressed 'concerns for patients' as relating to issues of privacy, consent, and ethics. Participants indicted that they believed that patients would object to the use of recording technology on the basis that it would be an unacceptable invasion of their privacy. In particular, they highlighted vulnerable patient populations or intimate care activities where the use of video monitoring might be deemed particularly problematic. There were also concerns that the presence of cameras could lead to issues of mistrust and impair relationship building between HCW and patients or their families. Participants indicated that cameras in 'public' areas were acceptable and possibly essential for 'staff safety' but there needed to be limits within the patient zone.

> ".. I think anywhere that .. there's patient privacy at risk .. for intimate examinations ... must be opt in only ... and it's got to be opt in for the patient as well as the staff members .. definitely got to be opt in for the patients ..." [REGISTRAR1].

Clarifying the consent process for the use of a video monitoring system in the patient zone was important. Participants expressed concerns and reluctance as to the potential for them to have to obtain consent from patients, citing reasons including a lack of time.

> "It's [obtaining consent] also a conversation that you've got to have ... plus you've got to deactivate the camera ... you just don't have time..." [REGISTRAR1].

Participants reported that collecting visual data only and no audio would help in terms of patient privacy and might reduce the risk of HCWs and patients 'self-censoring'. Meaning that HCWs or patients would be less likely to withhold information which was important, particularly if it might be considered to be incriminating or embarrassing.

Changes to feedback

Participants initially expressed concern that unlike direct observational auditing, the use of the video monitoring system would lead to a lack of feedback on practice and compliance:

> "This is one step removed again.. that it [feedback] would go away .. so how do people find out what.. you know how to improve ..." [NURSE1]

However, upon reflection and further discussion, the participants revealed that the provision of feedback in the clinical setting rarely occurred. Nurse 3, a current hand hygiene auditor, provided some possible reasoning for this, in that they would rather provide feedback to an educator or other key staff member in a general and non-identifying manner. When asked why, they responded;

> "It's not my role... I don't want to overstepping ...most especially just say if I was ... one junior nurses that was trained to audit... but then the nurse that's in there is senior ... it .. it makes me feel quite uncomfortable to be in that kind of position to let them know .. [NURSE3]

This suggests that a fear of a negative reaction to feedback could inhibit auditors from providing it. Further reflection by participants questioned the value of feedback in the clinical milieu. Participants spoke of the busyness of a clinical day and argued that in such situations it was hard to practice mindfully and to recognize your own actions if called to reflect upon them. They spoke of not being consciously aware and of being unable to recognize actions that they had recently undertaken, describing feedback in this context as;

> "some abstract concept of .. 5 minutes ago I saw you .... Not wash your hands before whatever... it's abstract." [NURSE1].

While recognizing the importance of learning, improving practice and of ensuring maximal patient safety, participants opined that this was not realistic during a busy clinical shift, as explained by one participant:

> You can't comfortably learn something if you know your house is burning down ... on wards for example things are moving so fast once you get pulled out of that engine .. unless someone's gonna help you .. which unfortunately they can't help you .. nothing happens .. so then when you're having this moment .. you're head's going ... Oh crikey ... I'm trying to enjoy this moment but all I can think about is ... the 4 patients that nothing's happening with..." [NSE2].

Following this line of thought, participants went on to suggest the benefits and possibilities inherent in using the footage recorded by a video monitoring system to provide feedback. Feedback they suggested could be given at an appropriate time and place so that participants could have capacity to fully reflect on their practice which they would be able to visualize and contextualize. This could be given privately or, if appropriate, in a group setting;

> "Watching back real time footage of what you do is ... is vital .... I though ... really like the idea of being able to do it in groups where we can all learn from each other ....look at it as a group and sort of people can say "oh yeah but I was doing this because of this" and kind of work out our practices and why we do it like that ..." [NURSE1].

Behavioral responses to the cameras

Participants reported previous experience and familiarity with direct observational auditing of hand hygiene behaviors. All expressed concern that the presence of the auditor during auditing affected their behavior, and that as a result the compliance which was recorded would not be realistically representative of typical practice, as illustrated;

> "REGISTRAR1: Yeah... I don't mind.. the only thing is that I think people 'up their game' when they can see ..
>
> NURSE2: Yeah it's not authentic...

REGISTRAR1: . . .. Someone watching . . . yeah

NURSE2: I see someone with a board.. I just would..

REGISTRAR1: You think about it more. . .

NURSE2: . . . yeah .. it's at the front of your head"

When asked to contrast the experience of being the subject of direct observational auditing with that of having their practice recorded during the scenario participants indicated that they quickly lost awareness of the cameras and were able to practice relatively naturally.

"I forgot . . . in all seriousness I .. at first I.. knew.. but I forgot.." [NURSE2]

" um . . . it was fine.. I mean obviously you know it's a SIM (Simulation).. I sort of forget the cameras were there.. it just sort of felt like another SIM really.. like it was fine. . ." [REGISTRAR1]

"To be honest at first it was kind of daunting .. but the moment that you just keep going in . . . because your main focus is the patient .. you're not focusing on those cameras .. when you walk in it .. like you know you kind of forget that it's there." [NURSE3]

However, one participant did quantify that a level of awareness would always remain;

" (LAUGHS)...you don't forget enough that you do something super dangerous. . ." [NURSE1].

Overall, the consensus was that footage captured by a video monitoring system would provide a more realistic representation of hand hygiene behavior, as one participant put it succinctly;

. . . I think that's more .. um .. like more akin to natural practice because then you start to forget that the cameras are there so yeah. [REGISTRAR1]

DISCUSSION

The aim of this study was to explore HCWs acceptability of video monitoring systems for auditing hand hygiene compliance. Direct observation is the internationally recognized gold standard for hand hygiene auditing, and yet its utility is increasingly being questioned.[14,39] This belief was a theme in preparatory work[9] and was also raised by participants in this study, who labeled data collected using direct observation as "not authentic". In contrast, they reported how they quickly lost awareness of the cameras and the recording process in the current study, which, as is supported by the literature, would lead to a reduction in the impact of the Hawthorn effect and other biases upon the data as compared to that collected by a live human observer[28,39,40] and hence result in a more accurate representation of hand hygiene compliance.

The literature describes not only the recording of HCW practice in a variety of different contexts, but also a range of responses to that recording from supportive and accepting, through ambivalence, embarrassment, and concern to outright hostility.[40-43] Participants discussed that the video footage could also capture a variety of other patient care activities and potentially HCW errors. A key feature of the literature and the results of this study were prominent concerns relating to a fear of consequences or reprisal the upshot of being "caught doing something wrong".[42] Scott, Watermeyer[44] suggests that such disquiet may arise from feelings of vulnerability due to the perceptions of HCWs that their practice is being scrutinized and that there may be unwanted "career or legal consequences" (p.17). Moreover, our findings support the contention that the culture in health care would still appear to have an overall punitive rather than 'no-blame' quality improvement focus which was found in earlier work.[9,44] Participants also discussed concerns around footage retention, access, and secure storage. All of this suggests that a considered, ethical, transparent, and well-communicated policy, outlining how video monitoring will be used for hand hygiene auditing, must be in place if HCW buy in is to be achieved.

Patient privacy is another issue which arises with any use of recording technology in health care. This is often the first concern that HCWs will raise when discussing the use of a video monitoring system and was the case in this study and previous work.[9] However, HCWs may raise patient privacy as a way of expressing their concerns not only about their own privacy but also their fears about negative outcomes as a result of having their practice recorded.[9,41] The issue of patient privacy is nonetheless complex and is an area that will require further investigation and clarification. Current legislation and guidance vary widely across jurisdictions and is also evolving as technological and societal changes occur. Cameras and other electronic tracking modalities are increasingly a part of everyday life ranging from closed circuit television in retail venues and public streets, telehealth, body cameras and mobile phone tracking capacity through to the so called "granny-cams" in aged care.[45,46] The question as to whether the possibility of enhanced quality and safety in health care using video monitoring outweighs the impacts on patient privacy is another area to be explored.

Study participants initially raised, but ultimately rejected, the loss of immediate feedback as a disadvantage of the use of video monitoring. This response echoes our earlier findings[9] where some participants disdained the utility of video monitoring on the basis of a presumed negative impact of the loss of immediate feedback whist others disagreed that this was a concern. Existing research[47-49] and our results, demonstrate that immediate feedback in the midst of a busy clinical day is not only rare but also often unwelcome, poorly received and of little benefit in terms of behavior change and overall practice improvement. Studies also show that the results of hand hygiene audits do not always reach frontline staff; are rarely received as individualized feedback; and often fail to motivate improvement efforts.[50]

However, it remains, that without performance feedback, staff will likely find it difficult to optimize hand hygiene practice. The potential for useful and powerful feedback using the real-time footage from video-monitoring was identified by participants in this study, who suggested viewing it at a later date to unpack hand hygiene practices and learn from collaborative discussions. This method of learning could be used to augment the more commonly used statistical audit feedback. The learning afforded by video-feedback of everyday practices has been shown to improve HCW and patients' understanding and practice of infection prevention and control (eg, Iedema, Hor et al. 2015, Wyer, Jackson et al. 2015, Hor, Hooker et al. 2016, Gilbert, Hor et al. 2020, Wyer, Hor et al. 2021). Hunukumbure, Smith et al. (2017) contend that video provides an authentic picture of practice and also has a "powerful impact on subsequent improvement" (p. 2). Study participants related how at times they were so caught up with their clinical work that they would practise habitually or automatically without being consciously aware of their actions. This aligns with findings in the literature that clinicians are often unaware of their practice gaps. It is argued that by reviewing recorded footage HCWs are able to recognize and reflect upon their actions and behaviours in a critical, yet ultimately positive way.[51-53]

CONCLUSIONS

HCWs who participated in the use of a video monitoring system for hand hygiene auditing revealed the potential benefits of this approach. However, they also expressed fears relating to negative feedback, punitive usage, and data security. Participants also expounded concerns for patients surrounding issues of privacy, ethics, and consent. These findings highlight the importance of exploring and ensuring factors surrounding acceptability to both HCWs and patients as a key part of any video monitoring system for hand hygiene implementation.

References

1. WHO. WHO Guidelines on Hand Hygiene in Healthcare. World Health Organization; 2009.
2. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. Lancet. 2000;356:1307–1312.
3. Grayson ML, Russo PL, Cruickshank M, et al. Outcomes from the first 2 years of the Australian national hand hygiene initiative. Med J Aust. 2011;195:615–619.
4. ACSQHC. National hand hygiene initiative manual. Australian Commission on Safety and Quality in Health Care; 2019.
5. Fisher DA, Seetoh T, May-Lin HO, et al. Automated measures of hand hygiene compliance among healthcare workers using ultrasound: validation and a randomized controlled trial. Infect Control Hosp Epidemiol. 2013;34:919–928.
6. Larson EL. Monitoring hand hygiene: meaningless, harmful, or helpful? Am J Infect Control. 2013;41(Suppl 5):S42–S45.
7. Pong S, Holliday P, Fernie G. Secondary measures of hand hygiene performance in health care available with continuous electronic monitoring of individuals. Am J Infect Control. 2018;47:38–44.
8. McLaws ML, Kwok YLA. Hand hygiene compliance rates: fact or fiction? Am J Infect Control. 2018;46:876–880.
9. McKay KJ, Ferguson PE, Shaban RZ. Methodological and technical considerations for video-based auditing of hand hygiene compliance in clinical practice: an exploratory study. Am J Infect Control. 2021;49:1384–1391.
10. McKay KJ, Shaban RZ, Ferguson P. Hand hygiene compliance monitoring: do video-based technologies offer opportunities for the future? Infect Dis Health. 2020;25:92–100.
11. Hagel S, Reischke J, Kesselmeier M, et al. Quantifying the Hawthorne effect in hand hygiene compliance through comparing direct observation with automated hand hygiene monitoring. Infect Control Hosp Epidemiol. 2015;36:957–962.
12. Wiemken TL, Furmanek SP, Mattingly WA, et al. Googling your hand hygiene data: using Google forms, Google sheets, and R to collect and automate analysis of hand hygiene compliance monitoring. Am J Infect Control. 2018;46:617–619.
13. Kwok YLA, Juergens CP, McLaws M-L. Automated hand hygiene auditing with and without an intervention. Am J Infect Control. 2016;44:1475–1480.
14. Srigley JA, Lightfoot D, Fernie G, et al. Hand hygiene monitoring technology: protocol for a systematic review. Syst Rev. 2013;2:101.
15. Storey SJ, FitzGerald G, Moore G, et al. Effect of a contact monitoring system with immediate visual feedback on hand hygiene compliance. J Hosp Infect. 2014;88:84–88.
16. Pires D, Pittet D. Hand hygiene electronic monitoring: are we there yet? Am J Infect Control. 2017;45:464–465.
17. Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Control. 2017;45:528–535.
18. WHO. Systematic literature review of automated/electronic systems for hand hygiene monitoring: preliminary results. 2013. [Accessed December 6, 2018] http://www.who.int/.
19. Gould DJ, Drey NS, Creedon S. Routine hand hygiene audit by direct observation: has nemesis arrived? J Hosp Infect. 2011;77:290–293.
20. Cheng VC, Tai JW, Chan WM, et al. Sequential introduction of single room isolation and hand hygiene campaign in the control of methicillin-resistant Staphylococcus aureus in intensive care unit. BMC Infect Dis. 2010;10:263.
21. Cohen B, Murray M, Jia H, et al. Is hand hygiene frequency associated with the onset of outbreaks in pediatric long-term care? Am J Infect Control. 2016;44:1492–1494.
22. Gould DJ, Chudleigh J, Drey NS, et al. Measuring handwashing performance in health service audits and research studies. J Hosp Infect. 2007;66:109–115.
23. Srigley JA, Furness CD, Baker GR, et al. Quantification of the Hawthorne effect in hand hygiene compliance monitoring using an electronic monitoring system: a retrospective cohort study. BMJ Qual Saf. 2014;23:974–980.
24. Sahud AG, Bhanot N, Radhakrishnan A, et al. An electronic hand hygiene surveillance device: a pilot study exploring surrogate markers for hand hygiene compliance. Infect Control Hosp Epidemiol. 2010;31:634–639.
25. Boyce JM. Electronic monitoring in combination with direct observation as a means to significantly improve hand hygiene compliance. Am J Infect Control. 2017;45:528–535.
26. Armellino D, Hussain E, Schilling ME, et al. Using high-technology to enforce low-technology safety measures: the use of third-party remote video auditing and real-time feedback in healthcare. Clin Infect Dis. 2012;54:1–7.
27. Haac B, Rock C, Harris AD, et al. Hand hygiene compliance in the setting of trauma resuscitation. Injury. 2017;48:165–170.
28. Clack L, Scotoni M, Wolfensberger A, et al. "First-person view" of pathogen transmission and hand hygiene – use of a new head-mounted video capture and coding tool. Antimicrob Resist Infect Control. 2017;6:108.
29. Diller T, Kelly JW, Blackhurst D, et al. Estimation of hand hygiene opportunities on an adult medical ward using 24-hour camera surveillance: validation of the HOW2 benchmark study. Am J Infect Control. 2014;42:602–607.
30. McKay KJ, Shabban RZ, Li C. Using video-based surveillance for monitoring hand hygiene compliance according to the WHO 5 moments framework: a pragmatic trial. Infect Control Hosp Epidemiol. Unpublished results.
31. Pineles LL, Morgan DJ, Limper HM, et al. Accuracy of a radiofrequency identification (RFID) badge system to monitor hand hygiene behavior during routine clinical activities. Am J Infect Control. 2014;42:144–147.
32. Masroor N, Doll M, Stevens M, et al. Approaches to hand hygiene monitoring: from low to high technology approaches. Int J Infect Dis. 2017;65:101–104.
33. NHMRC. National statement on ethical conduct in human research 2007. National Health and Medical Research Council; 2007. (Updated 2018).
34. Elo S, Kyngas H. The qualitative content analysis process. J Adv Nurs. 2008;62:107–115.
35. Duncan DF. Content analysis in health education research: an introduction to purposes and methods. Health Education. 2013;20:27–31.
36. Sandelowski M. Qualitative analysis: what it is and how to begin. Res Nurs Health. 1995;18:371–375.
37. Morse JM. Critical analysis of strategies for determining rigor in qualitative inquiry. Qual Health Res. 2015;25:1212–1222.
38. Nowell LS, Norris JM, White DE, et al. Thematic analysis: Striving to meet the trustworthiness criteria. Int J Qual Methods. 2017;16:1–13.
39. Gould DJ, Creedon S, Jeanes A, et al. Impact of observing hand hygiene in practice and research: a methodological reconsideration. J Hosp Infect. 2017;95:169–174.
40. Hu YY, Peyre SE, Arriaga AF, et al. Postgame analysis: using video-based coaching for continuous professional development. J Am Coll Surg. 2012;214:115–124.
41. Kim YJ, Xiao Y, Hu P, et al. Staff acceptance of video monitoring for coordination: a video system to support perioperative situation awareness. J Clin Nurs. 2009;18:2366–2371.
42. Le Bris A, Mazille-Orfanos N, Simonot P, et al. Parents' and healthcare professionals' perceptions of the use of live video recording in neonatal units: a focus group study. BMC Pediatr. 2020;20:143.
43. Scott Kruse C, Karem P, Shifflett K, et al. Evaluating barriers to adopting telemedicine worldwide: a systematic review. J Telemed Telecare. 2018;24:4–12.
44. Scott M, Watermeyer J, Wessels TM. Video-recording complex health interactions in a diverse setting: ethical dilemmas, reflections and recommendations. Dev World Bioeth. 2020;20:16–26.
45. van Dalen ASHM, Legemaate J, Schlack WS, et al. Legal perspectives on black box recording devices in the operating environment. Br J Surg. 2019;106:1433–1441.
46. Minuk L. Why privacy still matters: the case against prophylactic video surveillance in for-profit long-term care homes. Queen's LJ. 2006;32:224.
47. Azim S, Juergens C, Hines J, et al. Introducing automated hand hygiene surveillance to an Australian hospital: mirroring the HOW2 Benchmark Study. Am J Infect Control. 2016;44:772–776.
48. Azim S, McLaws ML. Doctor, do you have a moment? National hand hygiene initiative compliance in Australian hospitals. Med J Aust. 2014;200:534–537.
49. Boscart VM, Fernie GR, Lee JH, et al. Using psychological theory to inform methods to optimize the implementation of a hand hygiene intervention. Implement Sci. 2012;7:77.
50. Livorsi DJ, Goedken CC, Sauder M, et al. Evaluation of barriers to audit-and-feedback programs that used direct observation of hand hygiene compliance: a qualitative study. JAMA Netw Open. 2018;1:e183344.
51. Iedema R, Carroll K, Collier A, et al. Video-reflexive ethnography in health research and healthcare improvement: theory and application. CRC Press; 2019.
52. Hunukumbure AD, Smith SF, Das S. Holistic feedback approach with video and peer discussion under teacher supervision. BMC Med Educ. 2017;17:179.
53. Nilsen S, Baerheim A. Feedback on video recorded consultations in medical teaching: why students loathe and love it - a focus-group based qualitative study. BMC Med Educ. 2005;5:28.

Appendix E: Phase 1: Interview Question Guide.

Phase 1 Interview Question Guide

Description of the purpose of the study

This research study about **exploring** hybrid approach hand hygiene auditing methodologies that incorporates video based electronic surveillance.

Hand hygiene is an essential aspect of patient safety and hence auditing of healthcare worker practice is required in all public healthcare facilities in Australia under the auspices of the National Hand Hygiene Initiative. Data is collected by trained auditors using direct observation and while this method is considered the "gold standard" is it resource intensive in terms of auditor training, auditing time and data entry requirements. Furthermore, there are questions as to the potential impacts that the presence of an auditor may have on the behaviour of the healthcare workers who are being observed (known as the Hawthorne effect). In an attempt to improve auditing efficacy and accuracy of auditing, various electronic methods have been proposed however, none have been compatible with Australian data collection requirements. There is no published research that has examined the use of electronic collection methods for the 5 Moments specifically.

Phase one of this study proposes to explore and develop technical and methodological specifications for possible hybrid direct observation/electronic surveillance method of hand hygiene auditing.

State the formal research question to the participant

What is the utility of video surveillance methods for hand hygiene auditing according to the 5 Moments of Hand Hygiene compliance framework?

Question Guide

1. Are you currently a hand hygiene auditor?
    a. If so, for how long have you been auditing?
    b. Why did you choose/what motivated you to become an auditor?
    c. How many audits do you do per month, on average?

2. Can you describe how you undertake Hand Hygiene Auditing?
    a. Prompts may include:
    b. How often
    c. Duration of Session
    d. Overt vs Covert,

ASSUMING THAT DIRECT OBSERVATION IS BEING USED

3. In your experience, what are the advantages of the method you use for hand hygiene compliance monitoring?
    a. Possible prompts
        i. Feedback/education
        ii. Importance of HH
        iii. Context of compliance/non-compliance (inc HCW)
4. In your experience, what are the disadvantages of the method the method you used?
    a. Possible prompts
        i. Time/cost
        ii. HCW responses to feedback/being audited
        iii. Hawthorne effect/other biases/accuracy

5. What do you see as the purpose of DO auditing – what are we trying to achieve by conduction audits using this method
    a. POSSIBLE PROMPTS
        i. COLLECT DATA
        ii. CHANGE BEHAVIOUR
        iii. COMBINATION OF BOTH
            1. IF ii, or iii does this impact one the "accuracy" of the compliance rate
                a. Does this matter?

IF FOR SOME REASON THE PARTICIPANT IS NOT USING DIRECT OBSERVATION.

6. Have you heard of or do you know about the DIRECT OBSERVATION Method of Hand Hygiene auditing?

IF FAMILIAR WITH DIRECT OBSERVATION – PROCEED TO ADVANTAGES/DISADVATAGES QUESTIONS

ELECTRONIC COMPLIANCE MONITORING – eg dispenser activation, consumption, tag based systems

7. Have you ever used, trialled or had any experience of any electronic Hand Hygiene compliance monitoring systems now or in the past?
    a. Can you describe the system that you used – what was involved?
    b. What do you see as the advantages of this method of compliance monitoring?
    c. What do you see as the disadvantages of this method?

VIDEO RECORDING OF CLINICAL PRACTICE

8. Have you ever experienced the video recording of clinical practice – yours or others
9. Can you describe what was involved
10. How did you and your colleagues feel about this

OUR STUDY IS PROPOSING OPTIONS FOR HYBRID VIDEO-BASED AUDITING SYSTEM WITH CAMERAS LOCATED IN THE PATIENT ZONE AND AUDITORS REVIEWING THE FOOTAGE TO MEASURE COMPLIANCE

11. What are your impressions this as a concept or idea?
12. How would you feel about such a system?

13. What technical/structural features do you think such a system might need to be able to capture hand hygiene according to the WHO 5 moments – what would the system need to "look like" to collect the type of footage such that we could audit from

14. What do you think the advantages of such a system might be?
    a. Possible prompts
        i. Time/cost
        ii. Accuracy

15. What do you think the disadvantages of such a system might be?

16. What features of aspects of such a system might concern you or your colleagues or might be problematic in terms of introducing such a system (barriers)

17. What could be done or put in place to make such a system more workable/acceptable to for you and/or your team (enablers)?

18. Do you have any other comments or suggestions as to the utility of video based technologies for hand hygiene compliance monitoring

Appendix F: Phase 1: Human Research Ethics Committee, The University of Sydney – Phase 1: letter of Approval: Project 2019/387: May 2019.

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Tuesday, 28 May 2019

Prof Ramon Shaban
Clinical Nursing; Faculty of Medicine and Health
Email: ramon.shaban@sydney.edu.au

Dear Ramon,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.: **2019/387**
Project Title: **Video Based Electronic Surveillance for Hand Hygiene Auditing: An exploratory and evaluative study**
Authorised Personnel: **Shaban Ramon; Ferguson Patricia; McKay Kat;**
Approval Period: **28 May 2019** to **28 May 2023**
First Annual Report Due: **28 May 2020**

Documents Approved:

Date Uploaded	Version Number	Document Name
25/05/2019	Version 2	PIS - Clean
25/05/2019	Version 2	PCF - Clean
24/01/2019	Version 1	Sample Interview Questions
24/01/2019	Version 1	Sample Email Invitations

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of*

THE UNIVERSITY OF SYDNEY

Research, applicable legal requirements, and with University policies, procedures and governance requirements.

- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Dr Helen Mitchell
Chair
Human Research Ethics Committee (HREC 1)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007) and the NHMRC's Australian Code for the Responsible Conduct of Research (2007)

Appendix G: Phase 1: Eastern Health Office of research and Ethics: Letter of Approval to recruit at Eastern Health.

easternhealth

5 Arnold Street, Box Hill
Victoria 3128 Australia
PO Box 94, Box Hill 3128
Tel (03) 9895 3281
Fax (03) 9895 4896
info@easternhealth.org.au
ABN 68 223 819 017

www.easternhealth.org.au

Approval to Recruit at Eastern Health

08 August 2019

Eastern Health HREC
Ph: 03 9895 3398
Fax: 03 9094 9610
Email: ethics@easternhealth.org.au

Katherine McKay
Clinical Prevention and Control Services
Eastern Health

Dear Katherine McKay,

Study title: Video Based Electronic Surveillance for Hand Hygiene Auditing: An exploratory and evaluative study

Principal Investigator: Katherine McKay
HREC Approval: Univeristy of Sydney Human Research Ethics Committee (HREC), Project no: 2019/387

Thank you for your email with respect to recruitment of participants at Eastern Health.

It is understood the researcher associated with this study will invite Eastern Health staff via email to register interest to participate. Those who express interest will be provided a Participant Information Sheet and Consent Form to provide written informed consent to the study.

The Executive Director of Learning & Teaching/Chief Nursing & Midwifery Officer, Philippa Blencowe has approved the recruitment of participants at Eastern Health.

Kind Regards

[redacted]

Robert Reid
Ethics Governance and Project Officer
Eastern Health Office of Research and Ethics

Appendix H: Phase 1: Participant Information Statement.

THE UNIVERSITY OF SYDNEY

Susan Wakil School of Nursing and Midwifery
Faculty of Medicine and Health
University of Sydney

ABN 15 211 513 464

CHIEF INVESTIGATOR (SUPERVISOR)
Professor Ramon Z. Shaban
Clinical Chair of Infection Prevention and Control

Room 0.4.20
Westmead Institute for Medical Research
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 8627 3117
Email: ramon.shaban@sydney.edu.au
Web: http://www.sydney.edu.au/

Video Based Electronic Surveillance for Hand Hygiene Auditing: An exploratory and evaluative study

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study about a hybrid approach hand hygiene auditing that incorporates video based electronic surveillance.

Hand hygiene is an essential aspect of patient safety and hence auditing of healthcare worker practice is required in all public healthcare facilities in Australia under the auspices of the National Hand Hygiene Initiative. Data is collected by trained auditors using direct observation and while this method is considered the "gold standard" is it resource intensive in terms of auditor training, auditing time and data entry requirements. Furthermore, there are questions as to the potential impacts that the presence of an auditor may have on the behaviour of the healthcare workers who are being observed (known as the Hawthorne effect). In an attempt to improve auditing efficacy and accuracy of auditing, various electronic methods have been proposed however, none have been compatible with Australian data collection requirements. Phase one of this study proposes to explore and develop technical and methodological specifications for a hybrid direct observation/electronic surveillance method of hand hygiene auditing. Subsequent phases will involve trial and evaluation of the developed methodology.

You have been invited to participate in this study because you have expertise in and experience of direct observational hand hygiene auditing. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:

- Understand what you have read.
- Agree to take part in the research study as outlined below.
- Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:

- **Professor Ramon Z. Shaban**
  Principal Investigator & Supervisor
  University of Sydney and Western Sydney Local Health District
- **Ms Katherine J. McKay**
  Principal Investigator & Student Researcher
  University of Sydney & Eastern Health
- **Dr. Patricia E. Ferguson**
  Principal Investigator Associate Supervisor
  University of Sydney

Ms Katherine J. McKay is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This will take place under the supervision of Professor Ramon Z. Shaban and Dr Patricia E Ferguson.

(3) What will the study involve for me?

You are invited to participate in a brief interview, held at a time and place that is convenient and comfortable you. It is anticipated that the interview will take approximately 30 minutes or less and will discuss your thoughts and feelings about both the current "gold standard" method of direct human observational auditing and options, possibilities and ideas for a hybrid direct human/video based electronic surveillance model. We are seeking to understand what you see as both the positives and negatives of such an approach as well as things that would "make it work" and things that would "get in the way".

For the purpose of this research, this interview will be audio recorded. Audio recordings will be transcribed by researchers and will have names omitted to ensure confidentiality. These recordings will remain in a secure filing cabinet within the infection prevention and control office, Box Hill Hospital, Victoria. Should you wish to, a copy of the interview transcript will be available for you to review.

(4) How much of my time will the study take?

Approximately 30 minutes

(5) Who can take part in the study?

Individuals with expert knowledge and/or experience of auditing or overseeing or otherwise facilitating auditing of hand hygiene compliance are invited to participate in this study in order that a range of informed views, options and ideas on the topics of direct human observational auditing and a hybrid direct human/video based electronic surveillance model can be obtained. This may include, but is not limited to:

- Infection Prevention and Control Practitioners
- Experienced local/peer hand hygiene auditors
- Managers of areas where regular hygiene auditing takes place

- Those involved in the oversight of hand hygiene education, training or development programs

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney or Eastern Health.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by contacting any of the above listed researchers.

You are free to stop the interview at any time. Unless you say that you want us to keep them, any recordings will be erased and the information you have provided will not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. The benefits that may arise through your participation in this project are mostly altruistic in nature and may arise from knowing that you are advancing knowledge regarding how practice changes may be introduced in an effective and cost efficient way.

(9) What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to us collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

Audio recording of the interview will be transcribed and all names and other identifying information will be removed to ensure confidentiality. Anonymised transcripts will be stored in secure filing cabinet within the Infection Prevention and Control Office of Box Hill Hospital. Information will be retained for a period of 5 years, after which the information will be destroyed using confidential paper disposal service. Digital audio recordings will destroyed by deleting recorded information. Completed consent forms will be kept in a locked filing cabinet within the Infection Prevention and Control Office of Box Hill Hospital. Any information obtained in connection with this research project that can identify you will remain confidential and will only be used for the purpose of this research project. It will only be disclosed with your permission, except as required by law. In any publication and/or presentation, information will be provided in such a way that you cannot be identified, except with your permission. Unique identifiers will be allocated as a means of ensuring confidentiality and anonymity

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Ms Katherine McKay will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact any of the researchers

- Principal Investigator and Supervisor **Professor Ramon Z. Shaban**
  Email: ramon.shaban@sydney.edu.au
  Phone: +61 (0)2 8627 3117

- Principal Investigator and Student Researcher **Ms Katherine McKay**
  Email: kmck4637@uni.sydney.edu.au
  Phone: 0404809496

- Principal Investigator and Associate Supervisor **Doctor Patricia Ferguson**
  Email: Patricia.Ferguson@health.nsw.gov.au

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by ticking the box on the participant consent for and providing your contact details or by contacting any of the above listed researchers. This feedback will be in the form of a brief 1-2 page summary. You may also request copies of any publications arising from this study in the same manner. You will receive this feedback after the study is finished.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney **2019/387** As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

Appendix I: Phase 1: Participant Consent Form.

THE UNIVERSITY OF SYDNEY

ABN 15 211 513 464

Susan Wakil School of Nursing and Midwifery
Faculty of Medicine and Health
University of Sydney

CHIEF INVESTIGATOR (SUPERVISOR)
Professor Ramon Z. Shaban
Clinical Chair of Infection Prevention and Control

Room 0.4.20
Westmead Institute for Medical Research
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 8627 3117
Email: ramon.shaban@sydney.edu.au
Web: http://www.sydney.edu.au/

Video Based Electronic Surveillance for Hand Hygiene Auditing: An exploratory and evaluative study

PARTICIPANT CONSENT FORM

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

- I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.
- The researchers have answered any questions that I had about the study and I am happy with the answers.
- I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of Sydney or Eastern Health now or in the future.
- I understand that I can withdraw from the study at any time.
- I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.
- I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.
- I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

I consent to:

- **Audio-recording** YES ☐ NO ☐
- **Being contacted about future studies** YES ☐ NO ☐

I would like to review my interview transcripts YES ☐ NO ☐

I would like to receive feedback about the overall results of this study YES ☐ NO ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

☐ Postal: _____

_____

☐ Email: _____

.....
Signature

.....
PRINT name

.....
Date

Appendix J: Technical Specifications of the VMS trialled in Phase 2 (WPZ-NFC).

Technical specifications of novel VMS

1. Outline

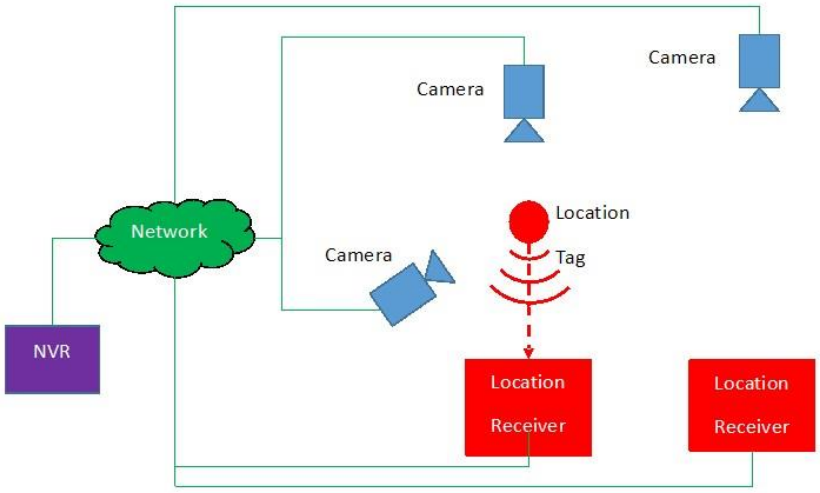
The proposed hand hygiene recording system has been designed to video/record participants hand hygiene behaviour while going about their normal duties. The system will allow video and meta-data recording of study participants with:

- no intervention required by the study participant, so to not modify normal behaviour.
- recordings of study participants only when they are in the study area as to eliminate footage not needed for the study.
- security of participant details and study footage

2. Operation

The proposed system comprises of 4 main components:

- Three IP Cameras
- Network Video Recorder (NVR)
- Location tags and receivers
- Data network



Simplified layout of the proposed hand hygiene recording system

showing multiple cameras and receivers

The IP Cameras will be positioned in locations to best capture the behaviour of the study participants, eg hand washing, patient interactions, entering/leaving areas.

The location tags and receivers are used to monitor the location of the study participants. The location of the tags, and therefore the participants, are monitored by the location receivers, which in turn relay relevant data to the NVR for data logging. If the tag is in a designated area for recording then the NVR will record the video feed from the camera monitoring that area, along with the tag information.

All the components are connected via a stand-alone wired local area network (LAN) and accessible via password protected logins. Being a network-based solution, future expansion would be economically possible.

Recording only when the participant is in the study area means only relevant footage is recorded, therefore:

- less time is needed to review footage
- less storage space is required, and therefore lower hardware cost
- footage of other people outside of the study, eg other staff members, patients, visitors, is limited

2.1 IP Cameras

The proposed cameras would be IP cameras which are industry standard cameras for surveillance recording and monitoring.

These cameras are supplied power and transmit video data (footage) over a data network which make installation quick and cost effective.

IP cameras can also have additional features which could assist in the study. Some of these features could be:

- Privacy mask: An area of the camera feed is blanked out, or blurred, to maintain privacy. This is done by the camera so the privacy area is unable to be removed from the recordings.

Privacy OFF Privacy ON

- Pre-recording: Video feeds can be recorded before the tag locations triggers a recording, eg record the 5 seconds before a participant enters the room.
- Infra-red / night recording: The ability to record in low/no-light conditions, eg at night with the lights off, using infra-red settings and illumination
- Sharing video feeds: IP Cameras can transmit video feeds to multiple devices. Therefore, a camera used for the hand hygiene study could also be used as a monitoring camera at nurses station or other locations to monitor falls, suicide risks, etc. at the same time as being used for the hand hygiene study.

Accessing the cameras on the network would be restricted and protected via passwords.

2.2 Location Tags and Receivers

The location tags are small devices that can be attached to keyrings or lanyards and require no intervention by the participant other than being carried on their persons. The batteries of the tag typically last for 6 – 12 months and therefore don't require charging or maintenance.

Receivers determine where the tag is located and transfer this information to the NVR to initiate, or stop, recording if a tag is in a specific location.

Each tag has a unique identifier number. The NVR will record the tag identifier not the participants personal information. It will be up to the study director to link the tag identifier with the participant.

This has the advantage that:

- The data recorded on the NVR, and therefore linked to a tag, remains anonymous
- The tag can be (re)used by multiple people, but at different times. Eg Tag 1 was used by nurse A on Monday, nurse B on Tuesday and doctor C on Wednesday.

2.3 NVR

The NVR records the information from the cameras and location receivers. The NVR is also where the study co-ordinator can access the recorded data.

Accessing the NVR is password protected and as well as the person needing to be physically connected to the network.

2.4 Network

The network used for this trial will be a small local area network, separate to any institution's existing network. All the components for the system will be physically connected to this network. This gives the advantages that:

- Access to the network is restricted to people with physical access to the network, in addition to the password restrictions on all the devices.
- No configuration is required by, or for, the local IT department
- No conflict with existing network infrastructure

3 Example log

An example data log could be:

Time Start	Time End	Tag ID	Location	Video File
01/03/2020_12:01:12	01/03/2020_12:03:22	001	Room 2	Cam02_234_01032020_120112
01/03/2020_13:13:32	01/03/2020_13:13:59	003	Room 1	Cam01_023_01032020_131332
01/03/2020_13:13:45	01/03/2020_13:21:22	001	Room 2	Cam02_278_01032020_131345
01/03/2020_13:15:10	01/03/2020_13:21:20	003	Room 2	Cam02_312_01032020_131510

Using this information all the data, including video, for tag “001” could be extracted and analysed.

Appendix K: Phase 2: Simulation Scenario Outlines for proof-of-concept trial in simulation.

Simulation Scenarios Outlines

Simulation 1 –Physical Assessment and History Taking

Scenario Title: HH – Scenario 1 – Physical Assessment and history taking
Target Audience: *Multi-disciplinary*
Original Author: Katherine McKay Date:

Learning Objectives):

1. Evaluation of the efficacy, accuracy and practicality of auditing hand hygiene via a VMS
2. Assessment of HCW reaction to video-based surveillance for hand hygiene auditing
3. "Warm Up" activities to familiarise participants with the process and setting
4. Performance of a physical assessment and history taking for a patient with headache, fatigue and fever

Brief summary of Scenario:
This scenario is essentially a "warm up activity" to allow the participants to become comfortable with the process and the setting. The scenario is a patient who has presented with a 3 day history of fatigue, headache and fever and involves interaction of various healthcare workers with a "patient" and their ongoing management of the "patient" over an approx. 20-30 minute period while they undertake and assessment and collect a history – the aim to simulate realistic HCW-patient interactions and to allow the participants to settle into the trial environment. The focus for the researchers is hand hygiene compliance and PPE usage monitoring via process of video recording and later review.
The timeline for the scenario is as follows
Scenario patient is a 35year old individual presenting to the emergency department with a 3 day history of fatigue, headache and for the last 24hrs intermittent fever.
Scenario Outline
Participants will be encouraged to interact with the patient, perform a physical assessment (cue cards with "results" to be provided following performance of each assessment element) obtain a hisrory and devise a plan of care
Scenario end point
Care plan devised

- **Age and Gender:**
  35 female
- **Past Medical History:**
  Smoker
  Obesity – 110kg
  Diabetes – type 2 (oral hypoglycemics)
  Anxiety/Depression
- **Allergies**
  Nil known
- **Social History:**
  Primary School teacher
  Single, Lives alone
  Social drinker
- **Medication:**
  Metformin – 1g BD
  Zoloft – 100mg mane

Facilitator role within the simulation: Introduction of patient to day staff and provision of patient parameters (eg. Vital signs, blood results, clinical cues)

Scenario Progression Information		
	Arrival on Ward - handover to day staff	
Baseline state	Introduction of patient to nursing staff	
HR: 110 R: 26		
BP: 140/80 Temp: 37.3		
SPO2: 95%		
Auscultation Sounds		
Lungs: ↓AE to bases, coarse BS, occasional expiratory wheeze		
Heart: NAD		
Bowel: abdo soft, normal bowel sounds		
Additional Information		
GCS: 15		
Disposition: headach 4/10		
Other:		
	Desired Learner Actions	
Next Event	Physical assessment History	
HR: 110 R: 28 Increased WOB		
BP: 150/80 Temp:38.2		
SPO2: 94%		
Auscultation Sounds		
Lungs: ↓AE to bases, coarse BS, occasional expiratory wheeze Dry cough		
Heart:		
Bowel:		
Additional Information		
GCS: 15		
Disposition: headache 5/10 Other: Patient complains feeling "cold", headache worse, rigors, temperature (38.2°), sore throat		
	Desired Learner Actions	
Next Event	Physical assessment Identification of potential influenza/CoViD Transmission based precautions NPS (Resp PCR) +/-Tamiflu Paracetamol if not administered previously	**Transition trigger completion of physical assessment and history taking** **Plan of care decided and documented**
HR:120 R:30		
BP: 130/70 Temp: 38.5°		
SPO2: 95%		
Auscultation Sounds		
Lungs: ↓AE to bases, coarse BS, expiratory wheeze Dry Cough		
Heart:		
Bowel:		
Additional Information		
GCS: 15		
Disposition: c/o sore throat, headache 7/10 , chills		
Heart: NAD Bowel:NAD		

Equipment Requirements

Equipment Required	Specifications
Simulated Patient (Actor)	Role 1: 35 year old (gender as per actor) with headache, fatigue and fever – physical assessment and history taking (warm up activity)
Room Set up General	Ward setting – bed, overbed table, locker, chair, commode Patient in PJ's (Own if preferred) with slippers and dressing gown Patient toiletries (toothbrush, toothpaste etc)
Food	Water jug and glass
General Patient Care Equipment	Medicine/pill cups Gloves, Gowns (assortment of PPE)
Monitoring/Equipment	Dynamap (Sphygnomometer) Tympanic thermometer Saturation probe IV Pump Glucometer
Paperwork	Patient Charts – Full admission pack Patient name band Pathology & radiology ordering slips

Patient "Script"

You are a 35 year old who has been unwell for the last 3 days or so You are obese and also have diabetes (treated with medication), as well as anxiety and depression. You are a primary school teacher, currently single and live on your own. You breed cockatiels as a pastime and currently have 27 at home in your avariary You were a very heavy smoker in the past but have cut down to about a pack a week in the last few years, you describe yourself as an "occasional" drinker. You take a couple of medications for your health conditions (although you can't really remember all the names) including a tablet for the diabetes and one for the anxiety. You check your blood glucose "most days" and you know it's a "bit high" usually 8-10. You usually have your flu vaccination each year You haven't travelled yourself recently – but Dan, your friend had a party last week and there were a lot of people there. Dan does work as a security guard at a quarantine hotel! You came to the Emergency Department because you have been feeling pretty unwell the last few days, really tired with headaches on and off. Last night you got really cold then really hot and sweaty, you didn't take your temperature as you don't have a thermometer at home AIM: *The aim of this scenario is for the healthcare workers to care for you in a safe manner – this will include identifying that you may have Influenza and starting precautions (isolation) appropriately – however the point is that* ***they*** *should come to this conclusion due to your symptoms (Fever, Cough, Sore throat etc) . You can provide them with the above information if they ask for it.*	
You are in a room in the ED – waiting to be assessed by the nursing and medical staff You are feeling a little "warm" and you have a headache, say 4/10 You didn't check your blood sugar this morning (if they ask you) Nursing staff should perform obs and ask you about your symptoms and history	Physical assessment and History by nursing staff – completion of "obs charts" etc

TRIGGER You start feeling cold and shivery, you are starting to get a sore throat and have a dry cough, your headache is worse TRIGGER (if needed) You are feeling WORSE – headache now 7/10, Chills, sore throat	Medical assessment and plan of care Eg – TBP, Respiratory PCR, CXR, panadol etc SCENARIO ENDS ONCE PLAN OF CARE DECIDED

Simulation 2 – A patient with an Infected Leg Wound

Scenario Title: HH – Scenario 2 – Patient with an Infected Leg Wound
Target Audience: *Multi-disciplinary*
- *Participants*
  - *Nurses 2*
  - *Doctors 1*

Original Author: Katherine McKay

Learning Objectives:
1. Evaluation of the efficacy, accuracy and practicality of auditing hand hygiene via a VMS
2. Assessment of HCW reaction to video-based surveillance for hand hygiene auditing
3. Management of a patient with an infected leg wound
4. Identification of the need for and application of Transmission based precautions

Brief summary of Scenario: *(I.S.B.A.R.)*

This scenario is a "typical" morning on a surgical ward – it involves interaction of various healthcare workers with a "patient" and their ongoing management of the "patient" over an approx. 1-1.5-hour period – the aim to simulate realistic HCW-patient interactions. The focus for researchers is hand hygiene compliance and PPE usage monitoring via the process of video recording using the developed novel video-based monitoring system (VMS) and then later review. The learning challenges for the participants is the appropriate management of the "patient" including the need for and application of transmission-based precautions.

The timeline for the scenario is as follows
Scenario patient is a 36-year-old individual who is being admitted to the general surgical ward from the Emergency Department where they presented from their GP with an infected leg wound. The patient had been on oral antibiotics for 5 days however the wound was looking worse and the entire lower leg was now cellulitic

Treatment in the ED included
- *IV Cannula and bloods*
- *Additional medications prescribed*
  - Flucloxacillin 1g QID
  - Clexane 40mg daily
  - Panadol 1g QID

Scenario Outline
Handover of patient to allocated "day shift" nurses (2)
Assessment of patient by day shift nurses – observations, safety checks etc.
Morning medications – as per medication chart
Routine care assistance with ADL's – e.g. sit out of bed, personal hygiene
Breakfast
Medical review
Additional treatments, investigation in response to review

- *Wound care*
- *Wound swab*
- *Initiation of TBP and CRE screen <u>if OS hospital stay identified</u> – patient to mention that suturing of limb occurred in a hospital in India and that they "stayed in" overnight*

Wound care and swab

Patient complains of diarrhoea

- *Initiation of TBP (if not already) in response to diarrhoea*
- *Faceal spec*

Morning Tea – END of Scenario

- **Age and Gender:**
  36, gender dependent on gender of actor "patient"
- **Allergies**
  Peanuts
  Morphine – Nausea, vomiting
- **Past Medical History:**
  Appendicectomy
  Mild Asthma/seasonal hayfever
- **Social History:**
  Married – 3 children 10, 7 & 5
  Non Smoker
  Social drinker
  Works in retail
- **Medication:**
  Multivitamin
  Ventolin "puffer" prn
  <u>Added in ED</u>
  - Flucox 1g QID
  - Clexane 40mg
  - Panadol

  <u>? Added by treating team</u>
  - Flagyl 500mg tds
- **Scenario end point** *(Trigger to end scenario): Arrival of patient (participants) morning tea*

Confederate / Educator Roles within the simulation

Handover of patient to day staff
Co-ordination of participant arrivals (eg meals, medical rounds, allied health assessment)
Provision of patient parameters (eg. Vital signs, blood results, clinical cues)

Scenario Progression Information			
		Handover to day staff	
Baseline state		Handover to "AM team" (see script below)	**If needed prompts re medications** **Wound not re-dressed or viewed overnight in ED** **Will probably need a swab** **Pt unable to weight bare due to painful leg** "GP letter" available - nil mention of admission to a hospital in India – just of the 5 days of oral antibiotics
HR: 70	R: 14		
BP: 115/70	Temp: 37.3		
SPO2: 99%			
Auscultation Sounds			
Lungs: Chest clear			
Heart: NAD			
Bowel: Slightly tender, mild nausea, BNO			
Additional Information			
GCS: 15			
Disposition: slept well, slight nausea Other: C/o Leg wound tender, hot IV patent right cubital fossa, site NAD			
		Desired Learner Actions	
Next Event		Care activities as per care plan Physical assessment Medications as per drug chart including IV ABX Requests SOOB and clean teeth pre breakfast Breakfast delivered Identification of need for medical review	**Modifiers in response to treatment** **Transition trigger – patient Wound red, hot, purulent (green exudate – sutures visible)** **If asked patient states that suturing occurred in a hospital in India** **Request Medical review**
HR: 90	R: 16		
BP: 110/70	Temp:37.6		
SPO2: 99%			
Auscultation Sounds			
Lungs: NAD			
Heart: 110			
Bowel: Abdo slightly tender, mild nausea – active BS			
Additional Information			
GCS: 15			
Disposition: c/o mild nausea, abdo discomfort			
Other: After "breakfast" Patient complains feeling "cold",			
		Desired Learner Actions	
Next Event		Review/assessment by home team Physical assessment Wound swab Identification of potential CRE/CPE CRE Screen Transmission based precautions Paracetamol if not administered	**Modifiers in response to treatment** **Identification of worsening of infection to leg wound** **Wound swab ordered** **Transition trigger – patient mentions treatment including overnight stay in Indian Hospital for leg suture** **CRE/CPE screen** **TBP**
HR:110	R:14		
BP: 110/65	Temp: 38.0^0		
SPO2: 99%			
Auscultation Sounds			
Lungs: NAD Heart: tachycardic			
Bowel: very active			
Additional Information			
GCS: 15			
Disposition: c/o nausea, abdo discomfort			
Other:			

Scenario Progression Information			
		Desired Learner Actions	
Next Event		Transmission based precautions in place Identification of potential Cdiff secondary to Antibiotics from GP Medical review o Spec for Cdiff o Antiemetic o Flagyl 500mg TBP in not previously initiated	**Modifiers in response to treatment** **Decreased temperature** **Diarrhoea** **Transition trigger – medical review completed**
HR: 90	R:14		
BP: 140/75	Temp: 37.2		
SPO2: 93%			
Auscultation Sounds			
Lungs: NAD			
Heart: NAD			
Bowel: Abdo pain, hyperactive bowel sounds			
Additional Information			
GCS: 15			
Disposition: nausea			
Other: episode of diarrhoea – mentions antibiotics from GP			
		Desired Learner Actions	
Next Event		Ongoing care as per general care plan Maintenance of enteric precautions CRE/Cdiff Screens Prescribed medications	**Modifiers in response to treatment** **Patient settles, starting to feel better** **Transition trigger –** **Arrival of morning tea – end of scenario**
HR: 85	R: 15		
BP: 115/70	Temp: 37.0		
SPO2: 99%			
Auscultation Sounds			
Lungs: NAD			
Heart: NAD			
Bowel:NAD			
Additional Information			
GCS: 15			
Disposition: nausea settles			
Other: nil further diarrhoea			

Equipment Requirements – Scenario 2

Equipment Required	Specifications
Simulated Patient (Actor)	Age "36", gender as chosen by actor patient, usually fit and well, medical presentation as per script
Room Set up General	Ward setting – bed, overbed table, locker, chair, commode Patient in PJ's (Own if preferred) with slippers and dressing gown Patient toiletries (toothbrush, toothpaste etc)
Food General Patient Care Equipment	Patient breakfast tray Water jug and glass Bed pan Sponge bowel Towels/facewashers Medicine/pill cups Gloves, Gowns (assortment of PPE)
Monitoring/Equipment	Dynamap (Sphygnomometer) Tympanic thermometer Saturation probe IV Pump Glucometer
Paperwork	Patient Charts – Full admission pack Patient name band Pathology & radiology ordering slips
Consumables	IV line x2 Bandage x3 IV Cannula Needles, Syringes Leg wound – dressed with bandage and combine Various wound consumables to subsequent allow wound care Specimen containers (faecal spec) Wound swab equipment
Medications and fluids	IV Flask (Normal saline) Water for injection/normal saline – 10 ml flush IV fluclox, flagyl, and maxalon SC clexane Oral medications - panadol
Airway adjuncts	Nil
Prosthetics	Nasty shin wound – sutured with purulent discharge Cdiff style loose diarrhoea

Patient "Script"

You are 36 years of age, married with 3 children aged 10, 7 & 5. You are generally fit and well with mild asthma/seasonal hay fever (you use a Ventolin puffer from time to time – eg when you get a cold). You are friendly and chatty. You work in retail selling high end sportswear

About 3 weeks ago your returned from India where you had been on a buying trip (Hotel quarantine was dreadful), whilst there – about 3 days before you came home - you cut your right shin when you fell down the steps at a temple. You went to the local hospital where they sutured the leg and you stayed overnight. You had a "drip" and received some medications; you think they were antibiotics. Initially things seemed ok, but a few days ago the wound started looking dodgy, leg was hot, red and swollen. You went to your GP who gave you some antibiotics (dicloxacillin 500mg, every 6 hours). Initially your leg seemed to be getting better but yesterday you noticed it was worse, there was lots of pus and it smelled "funny" you also started feeling a bit nauseated and had some abdominal discomfort – you went back to the GP who suggested that you should present to the Emergency department

It was very busy in the ED (full of crazy drunks) and they just put in a drip and gave you some more Antibiotics. You slept ok but your leg (which no one has looked at) is quite sore this morning and you are feeling a little "queasy".

The Simulation starts with your arrival on the ward and a hand over from the ED staff to the day nurses …

	This is Charli(e) a 36 year old xxxxxmale. Charli(e) this is (Nurse 1) and (Nurse 2) who will be looking after you this morning.
It would be good to interject as to how crazy it was in the ED with lots of "drunks" and "Crazy's"	*Charli(e) came up the ward overnight from the ED and has a cellulitic right lower leg 5 days of oral anitbiotics from the GP, but represented there yesterday with the wound getting worse and was sent into the ED – had an IV put in, started on IV fluclox - we've been pretty crazy in ED overnight*
If asked about your allergies – state that peanuts make your lips swell and you get short of breath and wheezy and you have this "injection thing" (Epipen) and that you vomit if you have morphine	*Obs wise – HR 70, RR, 14, 115/70, low grade temp 37.3 , Chest clear, abdo tender feeling a little nauseated, GSC 15, passing urine, the leg is getting a bit uncomfortable and not really weight bearing on it - the dressing hasn't been taken down but it is looking a bit hot and swollen.*
	Nothing much in terms of past history, a bit of mild asthma/seasonal hay fever – occasional Ventolin puffer, allergies are peanuts and morphine.

	IV site is fine, N/Saline 12 hourly with the 6/24 fluclox, otherwise on the drug chart there is just Panadol and some clexane
The morning staff should now perform a physical assessment – vital signs, check chart	*Basically, needs review and sorting out by the home team. Proper analgesia (declined Panadol earlier), antiemetic, wound swab…*
They may offer you some Panadol for pain (if so, decline at this time) … mention that your leg it a bit tender and feels hot. If you are asked to score the pain in your leg say it is a 3-4. Also mention that you are feeling a bit "queasy" but not too bad. Ask to go to the bathroom to clean your teeth before breakfast and sit out of bed to have breakfast. You will need some help getting out of bed because it is hard to walk due to your leg being sore.	Nurses should perform physical assessment Assist patient to clean teeth/SOOB as requested Administer medications (fluclox due 0800hrs) and offer panadol (declined by patient)
Breakfast delivered	
Eat breakfast (only a few mouthfuls) and thent complain of nausea and abdo discomfort and of feeling cold and "a bit shivery" (request dressing gown) leg now more painful – if asked to score 6/10	Repeat observations HR 90, BP 110/70, RR 16, T 37.6, SaO_2 99% Assessment of leg wound – noted to have sutures present, green purulent exudate – limb red and cellulitic
If asked about when the wound was sutured – state it was at the **clinic** in India – if asked if you were "Admitted" say yes overnight and it was horrible… noisy, dirty etc – but DON'T offer this information	Medical review should be triggered
A medical review should now occur … again if you are asked if you were hospitalized in India say that you were, if you are NOT asked make a point of mentioning how you were admitted to the hospital in India overnight where you had your wound "Stitched up" and you "got some medicine – you think might have been antibiotics" in a drip	May identify the need for a CRE screen due to overnight in Indian hospital Hx and physical assessment by medical team HR110, RR 16, BP 110/65, Temp 38.0, SaO_2 99%, Chest clear, abdo tender, c/o nausea and abdominal cramps, hyperactive bowel sounds. Wound red, hot swollen, purulent exudate, gaping sutures on view
You are feeling cold and shivery, your leg hurts (pain score 6/10), you feel sick (like you might spew) and your abdomen is crampy	Ideally should order….. o Wound swab o CRE screen o TBP o Antiemetic o May change Abx

If you are not offered pain relief – ask for some "Panadol" In you are not offered something for nausea ask for it You should be offered medication to relieve pain, fever and nausea – if you receive Panadol/a drug for nausea you will start feeling better. Your wound should be swabbed and redressed and you may be asked for a faecal (poo) specimen Complain that although the nausea is a lot better the cramps are getting worse and that you need to go to the toilet Report that you had "diarrhoea" (fake diarrhoea will be provided) – if you are not asked to provide a sample and are taken to the toilet, don't flush so that the nurses can see the diarrhoea Starting to feel a lot better – pain and nausea settled, no more diarrhoea – feeling warm – ask for help to remove dressing gown "MORNING" TEA ARRIVES	o Paracetamol Patient leg pain and nausea settles but c/o worsening abdo cramps Episode of loose, green, offensive stool Further medical review should be arranged Should consider… o ? Cdiff – send sample o TBP if did not pick up the CRE cue o ? flagyl if not already started Ongoing care as per general care plan HR 85, BP 115/70, RR 15, Temp 37, SaO_2 99% Pain and nausea settled, Maintenance of enteric precautions CRE/Cdiff Screens Prescribed medications End of Scenario

Simulation 3 – Care of a patient with Fatigue and Cough

Scenario Title: HH – Scenario 3 – Care of a patient with fatigue and cough

- *Participants*
  - *Nurses 2*
  - *Doctors 1*

Original Author: Katherine McKay Date:
Editing Author: Date:

Learning Objectives*:*

1. Evaluation of the efficacy, accuracy and practicality of auditing hand hygiene and PPE usage via a VMS
2. Assessment of HCW reaction to video-based surveillance for hand hygiene auditing
3. Management of a patient with suspected TB
4. Identification of the need for and application of Transmission based precautions

Brief summary of Scenario**:** *(I.S.B.A.R.)*

This scenario is a "typical" morning on a medical ward – it involves interaction of various healthcare workers with a "patient", and their ongoing management of the "patient" over an approx. 1 hour period. The aim is to simulate realistic HCW-patient interactions. The focus for researchers is hand hygiene compliance and PPE usage monitoring via the process of video recording, using the developed novel video-based monitoring system (VMS) and then later review. The learning challenge for the participants is the appropriate management of the "patient" including the need for and application of transmission based precautions.

The timeline for the scenario is as follows
Scenario patient is a 47-year-old individual who is being admitted to the general medical ward from the Emergency Department where they presented with a 4 week Hx of cough and fatigue – CoViD and Flu swabs by GP NAD, no recent travel or known contact with CoViD positive case.

Treatment in the ED included

- *IV Cannula and bloods*
- *Analgesia*
- *CXR - consolidation right lower lobe – not really clear – may need a CT*
- *Referral to respiratory unit*

Scenario Outline
Handover of patient to allocated "day shift" nurses (2).
Assessment of patient by day shift nurses – observations, safety checks etc.
Morning medications – as per medication chart.
Routine care assistance with ADL's – e.g. sit out of bed, personal hygiene .
Breakfast
Medical review.
Additional treatments, investigation in response to review.

- *Initiation of TBP due to suspicion of TB*
- *Request for sputum spec*

"Morning Tea" – END of Scenario

- **Age and Gender:**
  47, gender dependent on gender of actor "patient".
- **Allergies**
  Nil known.
- **Past Medical History:**
  Anxiety, Depression
  IBS – lactose intolerant
  Elevated Cholesterol
  Obese
  OA knees
- **Social History:**
  Married
  Ex-Smoker – quit about 10years ago
  Occasional THG
  Social drinker
  Accountant with the ATO
- **Medications:**
  Zoloft 100mg mane
  Multivitamin – daily
  Lactese (prn)
  Panadol oseto PRN
- **Scenario end point** *(Trigger to end scenario): Arrival of patient (participants) morning tea*

Confederate / Educator Roles within the simulation

Handover of patient to day staff
Co-ordination of participant arrivals (eg meals, medical rounds, allied health assessment)
Provision of patient parameters (eg. Vital signs, blood results, clinical cues)

Scenario Progression Information			
		Handover to day staff	
Baseline state		Handover to "AM team" (see script below)	
HR: 90	R: 22		
BP: 120/70	Temp: 37.0		
SPO2: 96%			
Auscultation Sounds			
Lungs: Coarse breath sounds, moist productive cough – yellow sputum			
Heart: NAD			
Bowel: NAD			
Additional Information			
GCS: 15			
Disposition: anxious, fed up, just wants to get answers			
Other:			
		Desired Learner Actions	
Next Event			**Modifiers in response to treatment**
HR: 90	R: 23	Care activities as per care plan	
BP: 120/70	Temp:37.3	Physical assessment – Vital Signs	
SPO2: 95%		Medications as per drug chart	
Auscultation Sounds		Requests SOOB and clean teeth pre breakfast	
Lungs: Coarse breath sounds, post breakfast haemotysis		Breakfast delivered	
Heart: NAD		Pt C/o haemoptysis	Seek medical review secondary to Haemoptysis
Bowel: NAD			
Additional Information			
GCS: 15 Disposition: Very anxious post haemotysis – increasing resp rate			
Other:			
		Desired Learner Actions	
Next Event			**Modifiers in response to treatment**
HR:85	R:28	Review/assessment by home team	**Identification of Suspected TB**
BP: 130/75	Temp: 37.4.0^0	Physical assessment	**TBP**
SPO2: 94%		Identification of potential TB	**CT Scan** **Sputum AFB** **+/- Oxygen**
Auscultation Sounds		Transmission based precautions	
Lungs: Course Breath sounds, moist cough – intermittent haemoptysis		Sputum for AFB CT Chest	
Heart: NAD			
Bowel: NAD			
Additional Information			
GCS: 15			
Disposition: remains anxious			
Other:			

Scenario Progression Information			
		Desired Learner Actions	
Next Event		Transmission based precautions in place Morning tea	**Arrival of morning tea – end of scenario**
HR: 88	R:22		
BP: 125/75	Temp: 37.1		
SPO2: 97%			
Auscultation Sounds			
Lungs: Coarse breath sounds, productive cough, no further haemoptysis Heart: NAD			
Bowel: NAD			
Additional Information			
GCS: 15			
Disposition: somewhat more settled but still "worried: about diagnosis			

Equipment Requirements

Equipment Required	Specifications (please place an X next to equipment required)
Simulated Patient (Actor)	47 year old, gender dependent on the actor, obese with a Hx of anxiety, depression, elevated cholesterol, IBS & OA knees. Presents with a 4 week Hx of fatigue and cough – respiratory swabs NAD
Room Set up	Ward setting – bed, overbed table, locker, chair, commode
General	Patient in PJ's (Own if preferred) with slippers and dressing gown Patient toiletries (toothbrush, toothpaste etc)
Food	Patient breakfast tray Water jug and glass
General Patient Care Equipment	Bed pan Sponge bowel Towels/facewashers Medicine/pill cups Gloves, Gowns (assortment of PPE)
Monitoring/Equipment Paperwork	Dynamap (Sphygnomometer) Tympanic thermometer Saturation probe IV Pump Glucometer Patient Charts – Full admission pack Patient name band Pathology & radiology ordering slips
Consumables	Bandage x1 IV Cannula Needles, Syringes Gloves, Gowns, N95 mask, Standard (assortment of PPE) Specimin container
Medications and fluids	Water for injection/normal saline – 10 ml flush Oral medications – Panadol, Zoloft,
Airway adjuncts	O2 mask/nasal cannula
Prosthetics	Blood Stained Sputum CXR suspicious of TB

Patient "Script"

You are a 47 year married individual. You work as an accountant for the ATO. You are overweight and not particularly fit due to the arthritis in your knees. You also have a medical history of Anxiety, depression, irritable bowel syndrome (lactose intolerant) and elevated cholesterol.

You have had an increasing cough over the last 4 weeks and have been feeling much more tired than usual. The cough is really annoying and some times you cough up creamy coloured muck, and your chest hurts. You've been to the GP and been tested for Flu and CoViD (and goodness knows what else), but the GP doesn't really know (and to be honest didn't really seem that interested. They just packed you off to the ED because your were feeling so awful and the cough was just getting worse

Part of the challenge of the simulation is for the staff to identify that you may have TB – they should do this by asking appropriate questions about your symptoms. Cough and fatigue are pretty non-specific symptoms – the red flags would be "unintentional weight loss" (if asked you can say you did seem to be loosing weight recently you think it might be maybe 8kg in the last couple of months). Night sweats is another symptom – you have been having night sweats – a female patient might pass these off as "change of life". As the scenario progresses you will experience a new symptom – blood stained sputum – this is another sentinel symptom. When this happens you should become very upset and anxious. If you are asked about overseas travel- you could mention that when you were much younger you spent a couple of years back-packing through India and Asia - you worked for a NGO in a Refugee camp in Thailand – many of the refugees were from India, Sri Lanka and Cambodia. You are not sure if people in the camp had TB (if you were asked about that). Your job was in the office but you did mingle with the residents and still have friends from that time. It would be natural for you to be worried that you have cancer, so you may be relieved when it is suggested that it may be TB

The Simulation starts with your arrival on the ward and a hand over from the ED staff to the day nurses …

This is Martin(a) a 47-year-old xxxxmale, martin(a) this is (Nurse 1) and (Nurse 2) who will be looking after you this morning.

Martin(a) was sent in to the ED yesterday afternoon by the GP – a 4 week Hx of worsening productive cough and increasing fatigue – all the respiratory swabs (flu, CoViD etc) were done by the GP and NAD

Obs wise – HR 90, RR, 22, 120/70, 37.1 , Chest coarse BS, productive cough, abdo soft, normal bowel sounds, GSC 15, passing urine, pain free

No allergies, PHx of Anxiety, Depression, IBS – lactose intolerant, Elevated Cholesterol and OA knees

You are feeling very tired after a night in the ED where it was noisy – you area also bothered by your cough, which is annoying and ongoing The morning staff should now perform a physical assessment – vital signs, check charts You should be given your normal morning medications If they ask you about things like night sweats (yes), or unintentional weight loss (yes), tell them that you have had these symptoms but don't offer the information unsolicited If asked about the colour of the sputum/phlegm/muck you have coughing up, report that it is CREAMY white (not blood stained at this point) Breakfast delivered Eat breakfast Post breakfast you experience a very bad coughing fit – when you look at the sputum on the tissue you see it is blood stained. You become very distressed/panniced. You become very short of breath and are coughing more A medical review should now occur. If the questions by the medical staff do not cover weight loss or night sweats/fevers you may have to mention this If they ask about overseas travel and/or contact with anyone with TB – mention the time working in the refugee camp. You are not AWARE of there being TB in the camp but you "guess it is likely that there was" You should be told that it is believed that you could have TB and you could be infectious	*No IV, but has had full bloods NAD, CXR was inconclusive – maybe it some RLL consolidation but they were not very good images – probably needs a CT* *Regular medications as per the drug chart – just Zoloft & a multivitamin, panadol prn for the OA* *Basically, needs review and sorting out by the home team.* Nurses should perform physical assessment Assist patient to clean teeth/SOOB as requested Administer medications Repeat observations HR 90, BP 120/80, RR 23, T 37.3, SaO_2 95% Haemoptysis noted Patient SOB, anxious Medical review should be triggered Hx and physical assessment by medical team HR85, RR 28, BP 130/75, Temp 37.4, SaO_2 94%, Chest coarse breath sounds, SOB, anxious, ongoing haemopysis. Abdo soft, normal bowel sounds. Ideally should order….. o TBP o +/- Oxygien o Chest CT o Sputum for AFB

You should be asked for a sputum specimen (which you are able to provide) and may be taken for a CT scan	Pt taken for CT (if ordered)
Post CT scan you may be told that you have a "lesion" in the lung – which could be TB	Verbal report from CT – dense consolidation of the right lower lobe, some enlarged lymph nodes and a small pleural effusion, there is a the suggestion of a small, thick walled cavitation approx. 4.5 cm in diameter, likely air filled.
"MORNING" TEA ARRIVES	Discussion of results with patient **End of Scenario**

Appendix L: Phase 2: Focus Group Question Guide

Focus Group Question Guide

Simulation Recording Using Fixed Camera Video Monitoring System (VMS)

Project VidPracWest

- Thank participants for taking part in the simulations and for agreeing to continue with the focus groups
- Remind participants that they may withdraw from the focus group at any point or decline to answer any questions
- Remind participants that the focus group will be audio recorded, transcribed and de-identified and that they may request a copy of the transcript
- Remind participants that they may request feedback as to overall results of the study

QUESTION GUIDE

1. How do you regard the importance of compliance with hand hygiene?
2. Are you aware how hand hygiene is audited – can you describe the process?
3. Have you had personal experience of hand hygiene auditing (being audited?)
4. How did you feel about this?
    a. Positive?
    b. Negative?
5. Have you had any experience of having your PPE usage audited
6. How did you feel about this?
    a. Positive?
    b. Negative?
7. How did you feel knowing your practice was being recorded today
    a. Positive?
    b. Negative?

The technology trialled today forms part of a proposed hybrid approach to hand hygiene auditing – the current auditing method is called direct observation. As has been described, direct observation involves a trained auditor being present in the clinical area, observing HCW practice and monitoring whether hand hygiene occurs according to the WHO 5 moments. However the data collected by direct observation is increasingly being called into question in terms of accuracy due to various biases, such as the Hawthorne effect and selection bias. It is estimated that the hand hygiene rate when an auditor is present may be more than twice what it is when they are not.

Under the hybrid model, direct observation would become more of an overt, educational process, auditors would use a brightly coloured vest or signage to indicate auditing was taking place and auditors and staff would be encouraged to make the processes about education and improvement.

The other arm of the hybrid approach would focus on the collection of accurate data via cameras such as was used today

1. How do you feel about this approach to Hand Hygiene and PPE usage auditing?
    a. Positive? Negative?
    b. Can you explain why you feel this way
2. Would you be interested in the opportunity to view the footage of your own practice?
    a. Why/why not?
3. How do you feel about the limitations as to who can see the footage (e.g. IPAC, Designated auditors) – should more/less people be able to view it?
4. How would you define.. OR … can you give examples of …
    a. Minor non-compliance
    b. "a mistake" or accident
    c. Serious misconduct

    How should each of these incidents be managed….?

Novel Video Monitoring System (VMS) Vs Fixed Cameras

The cameras used today record footage both constantly (fixed pre-existing cameras) as well as the system we have developed which records only when an activation tag carried by a participant is nearby to the camera. The tags are generic and do not identify specific individuals. The recorded footage would be reviewed at a later time by trained hand hygiene auditors. Footage would not be retained after auditing and the following guarantees would be given:

- Patients would be informed of the auditing process and have the chance to opt out
- Footage would normally be retained for 24-hours and then be deleted
- Auditing of hand hygiene compliance and PPE usage would be performed from the footage in a confidential manner by trained and validated hand hygiene auditors – the footage would only be able to be viewed by the designated auditor and a member of the IPAC service
- Public feedback of results (e.g. to managers) would be reported in a de-identified manner (HCW designation and moment). Personal, confidential, 1:1 feedback would be provided only upon request of the HCW and would be delivered in a positive and learning focused manner.
- Footage would not be utilised for any other purposes than those described and would not be used in staff appraisal, performance review or recorded on staff files excepting in the circumstances of major critical incident
- Major or critical incidents (e.g., criminal activities, patient or staff assault) would trigger a review process as per normal hospital policy and procedure.

5. How do you feel about this approach to Hand Hygiene and PPE usage auditing?
    a. Positive? Negative?
    b. Can you explain why you feel this way

6. Would you be interested in the opportunity to view the footage of your own practice?
    a. Why/why not?
7. How do you feel about the limitations as to who can see the footage (e.g. IPAC, Designated auditors) – should more/less people be able to view it?
8. How would you define.. OR … can you give examples of …
    a. Minor non-compliance
    b. "a mistake" or accident
    c. Serious misconduct

    How should each of these incidents be managed….?
9. What if anything would you want to change about the proposed hybrid approach and how it worked
10. Do you have any other things to add about your experiences today?

Appendix M: Human Research Ethics Committee, Western Sydney Local Health District – Phase 2: letter of Approval: Project 2020/PID03547.

Health
Western Sydney
Local Health District

Research Office File No: (6746)

Project ID	2020/PID03547
Ethics Ref:	2020/ETH03157
Governance Ref:	2020/STE05381

13 January 2021

Professor Ramon Shaban
Clinical Chair, Infection prevention and Disease Control
University of Sydney and Western Sydney Local Health District

Dear Prof Shaban

COVID Research Project: Video camera technology for auditing and monitoring healthcare worker infection prevention and control practices for COVID-19 and other high-consequence infectious diseases: An exploratory and evaluative study, Westmead Hospital

Your request to undertake the above COVID-19 research project was reviewed by the WSLHD HREC COVID Executive Committee, a subcommittee of members of the Human Research Ethics Committee (HREC) and the WSLHD Research Governance Office (RGO.)

The WSLHD HREC has been accredited by the NSW Ministry of Health as a lead HREC to provide the single ethical and scientific review of proposals to conduct research within the NSW public health system. This lead HREC is constituted and operates in accordance with the National Health and Medical Research Council's *National Statement on Ethical Conduct in Human Research* and the *CPMP/ICH Note for Guidance on Good Clinical Practice.*

This proposal meets the requirements of the National Statement and I am pleased to advise that the HREC has granted ethical approval of this research project to be conducted by you at:

- ☐ Westmead Hospital

The following documentation has been reviewed and approved by the HREC & the WSLHD RGO:

- ☐ HREA 2020/ETH03157, version 3 dated 8 December 2020
- ☐ Protocol version 2, dated 18 December 2020
- ☐ Participant Information and Consent Form, version 2 dated 18 December 2020
- ☐ Simulation Scenarios Outlines, version 2 dated 18 December 2020
- ☐ Interview Question Guide, version 1 dated 23 November 2020
- ☐ Audit Tool, version 1 dated 23 November 2020

HUMAN RESEARCH ETHICS COMMITTEE

Research Office, Level 2, REN Building
Westmead Hospital, Hawkesbury & Darcy Roads, Westmead NSW 2145
Telephone 02 8890 9007 Facsimile 02 9845 9636
Email: WSLHD-ResearchOffice@health.nsw.gov.au

WESTERN SYDNEY LOCAL HEALTH DISTRICT
ABN 48 702 394 764

WSLHD Office, Westmead Hospital Campus
Institute Road, Westmead NSW 2145
PO Box 533, Wentworthville NSW 2145
Telephone 02 8890 5555

- Video Footage Evaluation Tool, version 1 dated 23 November 2020
- Email Invitation - Healthcare Worker Participants , version 1 dated 23 November 2020
- Email Invitation – Actor Patients, version 1 dated 23 November 2020
- CCTV_AXIS Cameras_QRooms, version 1 dated 23 November 2020
- Focus Group Question Guide, version 1 dated 23 November 2020
- Personal Protective Equipment (PPE) usage Evaluation Tool, version 1 dated 23 November 2020

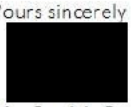
Please note the following conditions of approval:

- The chief investigator will immediately report anything which might warrant review of ethical approval of the project in the specified format, including unforeseen events that might affect continued ethical acceptability of the project.
- The chief investigator will immediately report any protocol deviation / violation, together with details of the procedure put in place to ensure the deviation / violation does not recur.
- Proposed amendments to the protocol or conduct of the research which may affect the ethical acceptability of the project, must be provided to the HREC & RGO to review in the specific format.
- The HREC must be notified, giving reasons, if the project is discontinued at a site before the expected date of completion.
- The Coordinating Chief Investigator must provide an annual report to the HREC and a final report at completion of the study, in the specified format. HREC approval is granted for a period of 12 months and ongoing approval is contingent upon annual submission. Annual Reports for all studies should be submitted in November, they will be processed and presented to the HREC at their January meeting. A copy of the Annual / Final Research Report Form can be obtained electronically from the Research Office on request.
- It should be noted that compliance with the ethical guidelines is entirely the responsibility of the investigators.
- Any non WSLHD research team members who will be conducting study visits within WSLHD site/s are to be accredited as an external researcher through the WSLHD Research and Education Network;

You are reminded that this letter constitutes *ethical approval only*. You must not commence this research project until separate authorisation from the Chief Executive or delegate has been obtained.

In all future correspondence concerning this study, please quote Research Office File number *(6746)*. The WSLHD Research Office wishes you every success in your research.

Yours sincerely



Mrs Patricia Fa
Secretary
WSLHD Human Research Ethics Committee

Appendix N: Phase 2: Participant information and consent form.

Health
NSW GOVERNMENT | Western Sydney Local Health District

Participant Information Sheet/Consent Form

Health/Social Science Research - *Adult providing own consent*

Westmead Hospital

Title	**Vide**o camera technology for auditing and monitoring healthcare worker infection prevention and control **prac**tices for COVID-19 and other high-consequence infectious diseases: An exploratory and evaluative study at **West**mead Hospital
Short Title	**VidPracWest**
Protocol Number	V.2_20201218
Project Sponsor	WSLHD
Coordinating Principal Investigator/ Principal Investigator	Professor Ramon Z. Shaban
Associate Investigators	Ms Katherine McKay Dr Patricia Ferguson Dr Cecilia Li Dr Keren Kaufman-Francis Dr Shizar Nahidi Dr Cristina Sotomayor-Castillo
Location	Department of Infectious Diseases, Westmead Hospital, WSLHD

This Participant Information Sheet/Consent Form tells you about the research project. It explains the processes involved with taking part. Knowing what is involved will help you decide if you want to take part in the research.

Please read this information carefully. Ask questions about anything that you don't understand or want to know more about. Before deciding whether or not to take part, you might want to talk about it with a relative, friend or local health worker.

Participation in this research is voluntary. If you don't wish to take part, you don't have to.

If you decide you want to take part in the research project, you will be asked to sign the consent section. By signing it you are telling us that you:
- Understand what you have read
- Consent to take part in the research project
- Consent to be involved in the research described
- Consent to the use of your personal and health information as described.

You will be given a copy of this Participant Information and Consent Form to keep.

Part 1 What does my participation involve?

1 Introduction

You will be given a copy of this Participant Information and Consent Form to keep.
You are invited to take part in this research project, which is called **Vid**eo camera technology for auditing and monitoring healthcare worker infection prevention and control **prac**tices for COVID-19 and other high-consequence infectious diseases: An exploratory and evaluative study at **West**mead Hospital (**VidPracWest**).

You have been invited because either;
• You are a Medical, Nursing or Allied Health team members of the Infectious Diseases Ward at Westmead Hospital. You were contacted via the office of the Service Director using staff email database – as such the research team do not have access to your contact details.
OR
• You are a student at the Department of Theatre and Performance Studies, University of Sydney. You were contacted via the office of the Department Chair using student email database – as such the research team do not have access to your contact details.

2 What is the purpose of this research?

The aim of this study is to establish the utility of a novel video monitoring system (VMS) for the auditing of hand hygiene practice according to the World Health Organization '5 Moments for Hand Hygiene' as well as for the correct, safe and effective use of personal protective equipment.

Ms Katherine J. McKay is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This will take place under the supervision of Professor Ramon Z. Shaban, Dr Patricia E. Ferguson and Dr Cecilia Li.

3 What does participation in this research involve?

You will be invited to participate in a simulated patient-care scenario, followed by a post-simulation focus groups and interviews.

The simulation patient care scenario exercises will take place at the Q-Class Rooms of the New South Wales Biocontainment Centre (NBC), Westmead Hospital. You will be asked to engage in a simulation of a "typical day" caring for a patient. The scenario will be recorded using the fixed cameras present in the facility for later analysis and review. Camera placement will minimise facial feature recording and we will use digital software to pixilate any identifiable features.

• If you are a healthcare worker, you will be provided with a script and props and asked to undertake the role of a healthcare worker and care for the patient.
• If you are a theatre/performance student and/or actor, you will be provided with a script and props and undertake the role of the patient.

Following the completion of each simulation exercise, a focus group will be held. While this is entirely voluntary, the focus group will be helpful in enabling you to explore your thoughts and feelings in response to the video-based auditing technology.

Focus groups will be conducted in a private meeting room on Level 7 of the Central Acute Services Building at Westmead Hospital (within the infectious diseases unit) and will take approximately one hour to complete. The focus groups include a set of questions with *no* personal information being collected. The focus groups will be audio recorded. Audio recordings will be transcribed, and unique identifiers will be allocated as a means of ensuring confidentiality and anonymity.

In addition, you will have the option to participate in an interview to further discuss your opinions of and reflections upon the recent simulation exercises in which you participated. This is entirely voluntary and will be on an individual basis, and will be conducted in a private, confidential and supportive manner. The interview will be conducted in a private meeting room on Level 7 of the Central Acute Services Building at Westmead Hospital (within the infectious diseases unit) and will take approximately 30 minutes to complete.

As part of this interview, you will be able to review the footage of your practice and provide your feedback on the experience. Interviews will be audio-recorded, transcribed and unique identifiers will be allocated as a means of ensuring confidentiality and anonymity.

All original electronic recordings of the interviews and focus groups will be permanently deleted in accordance with standards required by the National Statement on Ethical Conduct in Human Research.

The level of participation will determine the duration of your involvement. For healthcare workers, up to 8 hours (i.e. a full working day) will be required for the simulation exercises (2 x 2 hours), focus groups (2 x 1 hours) and interview (2 x 30 minutes). Students/actors may elect to participate for one or both simulation exercises.

Participation in this research study is voluntary. There are no costs associated with participating in this research project nor will you be paid to take part in the study. However, morning and afternoon tea will be provided during the simulation exercises. A certificate of participation and Continuing Education (CE) points will be available for healthcare workers and post simulation references will be provided if requested by students/actors.

4 Do I have to take part in this research project?

Participation in this research project is voluntary. If you do not wish to take part, you do not have to. If you decide to participate, but change your mind, you are free to withdraw from the project at any stage.

If you decide to take part, you will be given this Participant Information and Consent Form to sign and you will be given a copy to keep.

You may leave the simulation exercise, focus group or interview at any time if you do not wish to continue. You may refuse to answer any questions that you do not wish to answer.

Your decision whether to participate or not, or to take part and then withdraw, will not affect your routine care, your relationship with professional staff or your relationship with Western Sydney Local Health District or the Department of Theatre and Performance Studies at The University of Sydney.

5 What are the possible benefits of taking part?

Your participation and opinions will provide valuable information about how new video surveillance technologies can be used to monitor and audit infection prevention and control practices.

6 What are the possible risks and disadvantages of taking part?

There are no foreseeable risks of harm or discomfort to you. Only members of the research team will have access to the data. In the event that you experience distress or anxiety in relation to the simulation exercise, focus group or interview, they will be paused or ceased, and

appropriate psychological support will be provided by social workers available within the hospital as a part of your follow-up care.

7 What if I withdraw from this research project?

If you do consent to participate, you may withdraw at any time. If you decide to withdraw from the project, please notify the Coordinating Principal Investigator, Professor Ramon Z. Shaban. A member of the research team will inform you if there are any special requirements linked to withdrawing. If you do withdraw, you will be asked to complete and sign a 'Withdrawal of Consent' form; this will be provided to you by the research team.

If you decide to leave the research project, the investigators will not collect additional information from you. You should be aware that the data collected until the time you withdraw will form part of the research project results. If you do not want your data to be included, you must tell the investigators when you withdraw. Once the study is complete, you will not be able to withdraw any data that you have provided.

8 Could this research project be stopped unexpectedly?

This research project may be stopped unexpectedly for a variety of reasons. These may include reasons such as technical difficulties with venue or equipment.

9 What happens when the research project ends?

Once the research study is complete, the research team will analyse the data, generate a report and prepare the findings for publication in scientific journals.

Part 2 How is the research project being conducted?

10 What will happen to information about me?

By signing the consent form, you consent to the research team recording data about infection prevention and control practices and collecting and using your focus group and interview responses for the research study.

There is no information obtained in connection with this research project that can identify you. All collected information will remain confidential and will only be accessed by the investigators. No personal identifiers will be collected during the video recording, focus groups and interview, and all participants will be assigned a unique identifier. No data that identifies individual participant(s) will be reported in publications or presentations arising from the study.

The information you provide will only be used for the purpose of this research study, and will only be disclosed with your permission, except as required by law.

In accordance with relevant Australian privacy and other relevant laws, you have the right to request access to the information you have provided to the research team. You will only be able to request a copy of the data that you have provided. You will not have access or be able to request access to any data provided by another participant(s). Please inform the Coordinating Principal Investigator, Professor Ramon Z. Shaban, if you would like access to the data you have provided.

It is anticipated that the results of this research study will be published and/or presented in a variety of scientific forums. In any publication and/or presentation, information will be provided in such a way that you cannot be identified, except with your express permission.

All data will be stored on password-protected confidential servers within the Western Sydney Local Health District and the University of Sydney, Westmead Campus in accordance with prevailing legislation policies at both institutions. Records for this study will be stored securely for five years following publication of the results before destruction.

11 Complaints

If you suffer any distress or anxiety as a result of this research project, you should contact the research team as soon as possible. You will be assisted with arranging appropriate treatment and support provided by social workers available at the hospital as a part of your follow-up care.

12 Who is organising and funding the research?

This research study is being led by the Coordinating Principal Investigator, Professor Ramon Z. Shaban. This study is supported by funding received from the 2020 Seed Funding Grant from the Marie Bashir Institute at the University of Sydney.

The WSLHD may benefit financially from this research project if, for example, the project assists in any commercial enterprise.

You will not benefit financially from your involvement in this research project even if, for example, knowledge acquired from your information proves to be of commercial benefit to the WSLHD. In addition, if knowledge acquired through this research leads to discoveries that are of commercial value to WSLHD, the researchers or their institutions, there will be no financial benefit to you or your family from these discoveries.

No member of the research team will receive a personal financial benefit from your involvement in this research project (other than their ordinary wages).

13 Who has reviewed the research project?

All research in Australia involving humans is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this research project have been approved by the HREC of Western Sydney Local Health District (WSLHD).

This project will be carried out according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect the interests of people who agree to participate in human research studies.

14 Further information and who to contact

The person you may need to contact will depend on the nature of your query. If you want any further information concerning this project or if you have any problems which may be related to your involvement in the project, you can contact any of the following people:

Research contact person

Name	Professor Ramon Z. Shaban
Position	Coordinating Principal Investigator and Clinical Chair, Infection Prevention and Diseases Control (University of Sydney and WSLHD)
Telephone	(w): 02 8627 3117; (m): 0478 312 668
Email	Ramon.shaban@sydney.edu.au

Name	Ms Katherine McKay
Position	Principal Investigator and PhD Candidate
Telephone	+61 404 809 496
Email	kmck4637@uni.sydney.edu.au

For matters relating to research at the site at which you are participating, the details of the local site complaints person are:

Complaints contact person

Name	WSLHD Research Governance
Position	WSLHD Research Office
Telephone	02 8890 9007
Email	WSLHD-ResearchOffice@health.nsw.gov.au

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about being a research participant in general, then you may contact:

Reviewing HREC approving this research and HREC Executive Officer details

Reviewing HREC name HREC Executive Officer Name Telephone	WSLHD Human Research Ethics Committee Ms Kellie Hansen 02 8890 9007
Email	Wslhd-researchoffice@health.nsw.gov.au

Local HREC Office contact

Position Telephone	Research Governance Manager 02 8890 9007
Email	Wslhd-researchoffice@health.nsw.gov.au

Consent Form - *Adult providing own consent*

Title	**Vid**eo camera technology for auditing and monitoring healthcare worker infection prevention and control **prac**tices for COVID-19 and other high-consequence infectious diseases: An exploratory and evaluative study at **West**mead Hospital
Short Title	**VidPracWest**
Protocol Number	V.2_20201218
Project Sponsor	WSLHD
Coordinating Principal Investigator/ Principal Investigator	Professor Ramon Z. Shaban
Associate Investigators	Ms Katherine McKay Dr Patricia Ferguson Dr Cecilia Li Dr Keren Kaufman-Francis Dr Shizar Nahidi Dr Cristina Sotomayor-Castillo
Location	Department of Infectious Diseases, Westmead Hospital, WSLHD

Declaration by Participant

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research described in the project.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time during the project without affecting my future relationships with WSLHD and/or The University of Sydney.

I acknowledge that any regulatory authorities may have access to records **specifically related** to this project to monitor the research in which I am agreeing to participate. However, I understand my identity will not be disclosed to anyone else or in publications or presentations.

I understand that I will be given a signed copy of this document to keep.

- **I would like to receive copies of the focus group/Interview transcripts**
  YES ☐ NO ☐
- **I would like to receive feedback about the overall results of this study**
  YES ☐ NO ☐

Name of Participant (please print) _____

Signature _____ Date _____

Declaration by Researcher†

I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Name of Researcher† (please print)

Signature _____ Date _____

† An appropriately qualified member of the research team must provide the explanation of, and information concerning, the research project.

Note: All parties signing the consent section must date their own signature.

Form for Withdrawal of Participation - *Adult providing own consent*

Declaration by Participant

I wish to withdraw from participation in the above research project and understand that such withdrawal will not affect my relationships with the researchers, WSLHD or the University of Sydney.

Name of Participant (please print) _____

Signature Date

In the event that the participant's decision to withdraw is communicated verbally, the Senior Researcher must provide a description of the circumstances below.

Declaration by Researcher†

I have given a verbal explanation of the implications of withdrawal from the research project and I believe that the participant has understood that explanation.

Name of Researcher (please print) _____

Signature _____ Date _____

† An appropriately qualified member of the research team must provide information concerning withdrawal from the research project.

Note: All parties signing the consent section must date their own signature.

Appendix O: Phase 3: HCW online survey data collection tool (hard copy).

Healthcare workers' opinions about using novel video-based monitoring system (VMS) for hand hygiene auditing

Hand hygiene is an essential aspect of patient safety. Auditing of healthcare workers' hand hygiene practices is required in all public healthcare facilities in Australia.

To improve the efficacy and accuracy of auditing, various electronic methods have been proposed. We have developed a new approach to hand hygiene auditing, incorporating a novel video-based monitoring system. This new approach shows promise in terms of collecting more accurate hand hygiene compliance information.

This survey seeks to explore how acceptable the use of video camera technology is for the auditing and monitoring of healthcare workers' hand hygiene practices and other infection prevention and control behaviours. You have been invited to participate in this study because you are a member of :

Australian College of Nursing (ACN), orAustralasian College for Infection Prevention and Control (ACIPC), orAustralasian Society for Infectious Diseases (ASID)We would like you to complete a short, anonymous online survey comprising of three sections: a) demographics; b) using direct observation as a hand hygiene auditing method; and c) using a video-based monitoring system as a hand hygiene auditing method. It is anticipated that the survey will take 20-30 minutes to complete.

Participation in this study is completely voluntary and you do not have to take part. Your decision whether or not to participate will not affect your current or future relationship with ACN, ACIPC, ASID, the researchers, or anyone else at the University of Sydney and/or any other organisation. Submitting your completed survey is an indication of your consent to participate in the study. You can withdraw your responses any time before you have submitted the survey. Once you have submitted it, your responses cannot be withdrawn because they are anonymous and therefore we will not be able to tell which one is yours.

This study is being led by Professor Ramon Z. Shaban and a team of clinical and infection prevention and control researchers from the University of Sydney. Ms Katherine J. McKay is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This study has been approved by the Human Research Ethics Committee at The University of Sydney (2021/040).

For more information about the study please contact Principal Investigator Professor Ramon Z. Shaban via email: office.professor-shaban@sydney.edu.au or telephone: +61 2 8627 3117.

A copy of the Participant Information Statement for this study is available for you to review.

[Attachment: "AccVid_PIS_v2_20210617.pdf"]

By ticking the "I agree to participate" checkbox, you consent to participate in this study.

◯ I agree to participate

8. What best describes your training and experience in hand hygiene auditing?

- ◯ I am a current and validated hand hygiene auditor
- ◯ I have been a validated hand hygiene auditor in the past, but am not one currently
- ◯ I have successfully completed hand hygiene auditor training, but am not a validated auditor
- ◯ I am not a hand hygiene auditor and have not completed any training

SECTION B: DIRECT OBSERVATION METHOD FOR HAND HYGIENE AUDITING

The current method of collecting information about hand hygiene compliance is called direct observation. It involves a trained hand hygiene auditor being present in the clinical area, observing HCW practice and comparing it to the World Health Organization's Five Moments of Hand Hygiene framework.

9. How many years of hand hygiene auditing experience do you have as of 1st January 2021?

_____

10. How would you describe your auditing style?

- ◯ Highly overt - I use special clothing and/or signage, I announce what I am doing and there is lot of interaction and feedback during the audit.
- ◯ Overt - I do not use special clothing and/or signage, but I announce what I am doing and interact with HCWs during the audit.
- ◯ Discreet - I do not tell HCWs what I am doing UNLESS they ask. I give feedback but only after auditing is complete.
- ◯ Covert - Auditing is disguised as some other activity and I only stop if HCWs work out what I am really doing.

11. How often do you offer feedback or education for HCWs' practice and compliance?

- ◯ Never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always

12. How do you provide your feedback?

- ◯ During the audit
- ◯ After the audit
- ◯ Only when asked by HCW
- ◯ Do not provide face-to-face feedback
- ◯ Written report sent via email directly to HCW
- ◯ Written report sent via email directly to manager/supervisor of HCW
- ◯ Other (please specify below)

_____

13. When it comes to giving feedback, please rate your level of agreement with the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
It is important to give feedback in real time	◯	◯	◯	◯	◯
I love being able to give feedback and educate HCWs	◯	◯	◯	◯	◯

Providing feedback to other HCW makes me feel uncomfortable	○	○	○	○	○
Giving feedback is part of the job	○	○	○	○	○

14. When giving feedback, have you ever encountered any of the following negative reactions? Please select all that apply?

- ☐ I have never experienced a negative reaction
- ☐ Being ignored
- ☐ Defensive body language
- ☐ Gestures (e.g., eye rolling)
- ☐ Negative comments (e.g., insults)
- ☐ Being yelled at
- ☐ Having a door shut OR curtains drawn in your face
- ☐ Other (please specify below)

_____

15. Do you think that the compliance rate gathered by direct observation would be reflective of current "normal" hand hygiene behaviours?

- ○ Yes - I think the rates would be fairly similar
- ○ No - I think practice would normally be much better (the true rate is higher than the rate gathered by direct observation)
- ○ No - I think practice would normally be much worse (the true rate is lower than the rate gathered by direct observation)

16. Please rate your level of agreement with the following statements about YOUR feelings when an auditor is directly observing YOUR hand hygiene practice.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I don't mind my practice being observed by the auditor	○	○	○	○	○
I think having the auditor present in the clinical area is an invasion of the patient's privacy	○	○	○	○	○
I prefer it when the auditor is open about their auditing	○	○	○	○	○
I appreciate it when the auditor interacts with me and offers me feedback about my practice	○	○	○	○	○
I prefer the auditor not to offer me feedback	○	○	○	○	○
Receiving feedback makes me feel stressed and nervous	○	○	○	○	○
Receiving feedback makes me feel like I am being "picked on"	○	○	○	○	○

I think that having the auditor present to watch my practice and record compliance is a good method	○	○	○	○	○
If I realise hand hygiene auditing is taking place, I become more aware of my hand hygiene practices	○	○	○	○	○
Being audited makes me uncomfortable	○	○	○	○	○
I find auditing to be intrusive	○	○	○	○	○
I worry that I will make a mistake and get "into trouble" while I am being watched	○	○	○	○	○
My hand hygiene practices remain the same, regardless of the presence of an auditor	○	○	○	○	○
I would prefer NOT to know that auditing is taking place	○	○	○	○	○

17. In your experience of having YOUR PRACTICE audited using the direct observation method, how often would the auditor offer you feedback or education about your practice and compliance?

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always

18. How was this feedback or education delivered to you?

- ○ Face-to-face
- ○ Written report sent via email directly to you
- ○ Written report sent via email directly to your manager/supervisor
- ○ Other (please specify below)

_____

19. Please rate your level of agreement with the following statements about the advantages and disadvantages of Direct Observation as an auditing method for hand hygiene practices.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Presence of auditors are a good reminder to HCWs about the importance of hand hygiene	○	○	○	○	○
Direct observation allows immediate feedback to be given to HCWs	○	○	○	○	○

Auditors can provide education about correct hand hygiene practices in the clinical setting	○	○	○	○	○
Direct observation allows auditors to notice problems in the clinical area that need to be addressed (e.g. work flow, product placement)	○	○	○	○	○
Receiving feedback about poor compliance can result in loss of confidence for HCWs	○	○	○	○	○
Direct observation is a resource intensive method (e.g. time consuming and costly)	○	○	○	○	○
Direct observation leads to a short-term increase in hand hygiene compliance while the auditor is present	○	○	○	○	○
Compliance rates from direct observation auditing are inaccurate	○	○	○	○	○

SECTION C: A NOVEL VIDEO-BASED MONITORING SYSTEM FOR HAND HYGIENE AUDITING

As an alternative to direct observation auditing, we have established a new approach for hand hygiene auditing. This novel video-based monitoring system involves a validated hand hygiene auditor reviewing a healthcare worker's hand hygiene practices via footage recorded during patient care.

Imagine this scenario taking place. You are told in a ward meeting that a new approach to hand hygiene auditing is to be trialed on your ward. A video-based monitoring system is going to be used to collect data. This will involve the placement of cameras in the patient zone (e.g. on the ceiling, above the head of the bed). These cameras only activate in the presence of a HCW via a proximity tag and record HCW-patient interactions.

This recorded footage would then be audited for hand hygiene compliance. This will be done in a confidential manner using de-identified video footage (e.g. faces will be blurred out). Once the auditing is complete, the footage will be permanently deleted and the information gained will be used to improve HCW practice, and therefore the quality and safety of patient care.

You are told that patients will be informed of the auditing process and have the chance to opt out. You are asked to participate and have your hand hygiene practices audited using the video-based monitoring system.

20. The following are some proposed features of the novel VMS. Please indicate whether you believe if these features are important.

	Not at all important	Not important	Neutral	Somewhat important	Very Important
Not recording audio	○	○	○	○	○
Warning light that recording is taking place	○	○	○	○	○
Audible tone when recording starts	○	○	○	○	○
Camera placed directly overhead	○	○	○	○	○
Camera place behind the head of the bed	○	○	○	○	○
Facial blurring or pixelation	○	○	○	○	○
Cameras only record when the HCW is present	○	○	○	○	○

There is the option to turn the cameras off at any time during patient care	○	○	○	○	○
Patients can turn the cameras off	○	○	○	○	○
Healthcare workers can turn the cameras off	○	○	○	○	○

21. Please rate your level of agreement with the following statements relating to the novel video-based monitoring system (VMS):

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Compliance rates for hand hygiene would be more accurate when collected by novel VMS than by direct observation	○	○	○	○	○
The use of the novel VMS would be an invasion of patient privacy	○	○	○	○	○
I would be unhappy about having my hand hygiene practice recorded	○	○	○	○	○
I would be concerned about the security, confidentiality and storage of the recorded footage	○	○	○	○	○
I would worry that any hand hygiene mistakes I make in the footage could be used as evidence against me	○	○	○	○	○
The use of the novel VMS would cause me to feel that I could not trusted	○	○	○	○	○
The use of the novel VMS would cause me to feel like "Big Brother" is watching	○	○	○	○	○
I would be concerned about the footage being used for other purposes that are not hand hygiene-related	○	○	○	○	○
Once in the patient room, I would soon forget about the presence of the cameras	○	○	○	○	○
Patients would be accepting of the use of the novel VMS for hand hygiene practices	○	○	○	○	○

I would feel comfortable with the use of such technology to monitor hand hygiene compliance	○	○	○	○	○
Being able review the footage of my hand hygiene practices with an auditor would be useful for my training and learning	○	○	○	○	○
Auditing using the novel VMS footage would be faster and less resource-intensive	○	○	○	○	○

22. Please rate your level of agreement with the following statements regarding how you would feel about your recorded footage being used for other purposes which are not hand hygiene-related:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Deliberate injury/assault of a patient	○	○	○	○	○
Assault of a staff member	○	○	○	○	○
Theft	○	○	○	○	○
Patients or visitors tampering with medical devices	○	○	○	○	○
Medical negligence	○	○	○	○	○
Correct use of personal protective equipment (e.g. gloves, masks, gowns)	○	○	○	○	○
No, it should only be used for auditing of hand hygiene practices	○	○	○	○	○

23. Which is your preferred method for hand hygiene auditing in all healthcare facilities?

- ○ Direct observation
- ○ Novel VMS
- ○ Combination of both

24. Please explain why you feel this way?

_____

25. If novel VMS were to replace direct observation, how acceptable is this method to you as an auditor?

- ○ Very unacceptable
- ○ Unacceptable
- ○ Neutral
- ○ Acceptable
- ○ Very acceptable

SECTION B: DIRECT OBSERVATION METHOD FOR HAND HYGIENE AUDITING

The current method of collecting information about hand hygiene compliance is called direct observation. It involves a trained hand hygiene auditor being present in the clinical area, observing HCW practice and comparing it to the World Health Organization's Five Moments of Hand Hygiene framework.

9. Have you experienced having your hand hygiene practice audited via direct observation?
- ◯ Yes
- ◯ No

10. Please rate your level of agreement with the following statements about how you felt or how you would feel when an auditor is directly observing your hand hygiene practice.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I don't mind my practice being observed by the auditor	◯	◯	◯	◯	◯
I think having the auditor present in the clinical area is an invasion of the patient's privacy	◯	◯	◯	◯	◯
I prefer it when the auditor is open about their auditing	◯	◯	◯	◯	◯
I appreciate it when the auditor interacts with me and offers me feedback about my practice	◯	◯	◯	◯	◯
I prefer the auditor not to offer me feedback	◯	◯	◯	◯	◯
Receiving feedback makes me feel stressed and nervous	◯	◯	◯	◯	◯
Receiving feedback makes me feel like I am being "picked on"	◯	◯	◯	◯	◯
I think that having the auditor present to watch practice and record compliance is a good method	◯	◯	◯	◯	◯
If I realise hand hygiene auditing is taking place, I become more aware of my hand hygiene practices	◯	◯	◯	◯	◯
Being audited makes me uncomfortable	◯	◯	◯	◯	◯
I find auditing to be intrusive	◯	◯	◯	◯	◯

I worry that I will make a mistake and get "into trouble" while I am being watched	○	○	○	○	○
My hand hygiene practices remain the same, regardless of the presence of an auditor	○	○	○	○	○
I would prefer NOT to know that auditing is taking place	○	○	○	○	○

11. In your experience of having your practice audited using the direct observation method, how often would the auditor offer you feedback or education about your practice and compliance?

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always

12. How was this feedback or education delivered to you?

- ○ Face-to-face
- ○ Written report sent via email directly to you
- ○ Written report sent via email directly to your manager/supervisor
- ○ Other (please specify below)

13. Please rate your level of agreement with the following statements about the advantages and disadvantages of Direct Observation as an auditing method for hand hygiene practices.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Presence of auditors are a good reminder to HCWs about the importance of hand hygiene	○	○	○	○	○
Direct observation allows immediate feedback to be given to HCWs	○	○	○	○	○
Auditors can provide education about correct hand hygiene practices in the clinical setting	○	○	○	○	○
Direct observation allows auditors to notice problems in the clinical area that need to be addressed (e.g. work flow, product placement)	○	○	○	○	○
Receiving feedback about poor compliance can result in loss of confidence for HCWs	○	○	○	○	○
Direct observation is a resource intensive method (e.g. time consuming and costly)	○	○	○	○	○

Direct observation leads to a short-term increase in hand hygiene compliance while the auditor is present	○	○	○	○	○
Compliance rates from direct observation auditing are inaccurate	○	○	○	○	○

SECTION C: A NOVEL VIDEO-BASED MONITORING SYSTEM FOR HAND HYGIENE AUDITING

As an alternative to direct observation auditing, we have established a new approach for hand hygiene auditing. This novel video-based monitoring system involves a validated hand hygiene auditor reviewing a healthcare worker's hand hygiene practices via footage recorded during patient care.

Imagine this scenario taking place. You are told in a ward meeting that a new approach to hand hygiene auditing is to be trialed on your ward. A video-based monitoring system is going to be used to collect data. This will involve the placement of cameras in the patient zone (e.g. on the ceiling, above the head of the bed). These cameras only activate in the presence of a HCW via a proximity tag and record HCW-patient interactions.

This recorded footage would then be audited for hand hygiene compliance. This will be done in a confidential manner using de-identified video footage (e.g. faces will be blurred out). Once the auditing is complete, the footage will be permanently deleted and the information gained will be used to improve HCW practice, and therefore the quality and safety of patient care.

You are told that patients will be informed of the auditing process and have the chance to opt out. You are asked to participate and have your hand hygiene practices audited using the video-based monitoring system.

14. The following are some proposed features of the novel VMS. Please indicate whether you believe if these features are important.

	Not at all important	Not important	Neutral	Somewhat important	Very Important
Not recording audio	○	○	○	○	○
Warning light that recording is taking place	○	○	○	○	○
Audible tone when recording starts	○	○	○	○	○
Camera placed directly overhead	○	○	○	○	○
Camera place behind the head of the bed	○	○	○	○	○
Facial blurring or pixelation	○	○	○	○	○

Cameras only record when the HCW is present	○	○	○	○	○
There is the option to turn the cameras off at any time during patient care	○	○	○	○	○
Patients can turn the cameras off	○	○	○	○	○
Healthcare workers can turn the cameras off	○	○	○	○	○

15. Please rate your level of agreement with the following statements relating to the novel video-based monitoring system (VMS):

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Compliance rates for hand hygiene would be more accurate when collected by the novel VMS than by direct observation	○	○	○	○	○
The use of the novel VMS would be an invasion of patient privacy	○	○	○	○	○
I would be unhappy about having my hand hygiene practice recorded	○	○	○	○	○
I would be concerned about the security, confidentiality and storage of the recorded footage	○	○	○	○	○
I would worry that any hand hygiene mistakes I make in the footage could be used as evidence against me	○	○	○	○	○
The use of the novel VMS would cause me to feel that I could not be trusted	○	○	○	○	○
The use of the novel VMS would cause me to feel like "Big Brother" is watching	○	○	○	○	○
I would be concerned about the footage being used for other purposes that are not hand hygiene-related	○	○	○	○	○
Once in the patient room, I would soon forget about the presence of the cameras	○	○	○	○	○

Patients would be accepting of the use of the novel VMS for hand hygiene practices	○	○	○	○	○
I would feel comfortable with the use of such technology to monitor hand hygiene compliance	○	○	○	○	○
Being able to review the footage of my hand hygiene practices with an auditor would be useful for my training and learning	○	○	○	○	○
Auditing using the novel VMS footage would be faster and less resource-intensive	○	○	○	○	○

16. Please rate your level of agreement with the following statements regarding how you would feel about your recorded footage being used for other purposes which are not hand hygiene-related?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Deliberate injury/assault of a patient	○	○	○	○	○
Assault of a staff member	○	○	○	○	○
Theft	○	○	○	○	○
Patients or visitors tampering with medical devices	○	○	○	○	○
Medical negligence	○	○	○	○	○
Correct use of personal protective equipment (e.g. gloves, masks, gowns)	○	○	○	○	○
No, it should only be used for auditing of hand hygiene practices	○	○	○	○	○

17. Which is your preferred method for hand hygiene auditing in all healthcare facilities?

- ○ Direct observation
- ○ Novel VMS
- ○ Combination of both

18. Please explain why you feel this way?

_____

19. If novel VMS were to replace direct observation, how acceptable is this method to you?

- ○ Very unacceptable
- ○ Unacceptable
- ○ Neutral
- ○ Acceptable
- ○ Very acceptable

ADDITIONAL COMMENTS	
Do you have any other comments to make about direct observation, and/or novel VMS as a hand hygiene audit tool?	_____
If you wish to receive a brief summary of the study results, please provide your email address:	_____

Appendix P: Phase 3: Patient online survey data collection tool (hard copy).

Healthcare consumers' opinions about using novel video-based monitoring system (VMS) for hand hygiene auditing

Hand hygiene is an essential aspect of patient safety. Auditing of healthcare workers' hand hygiene practices is required in all public healthcare facilities in Australia.

To improve the efficacy and accuracy of auditing, various electronic methods have been proposed. We have developed a new approach to hand hygiene auditing, incorporating a novel video-based monitoring system. This new approach shows promise in terms of collecting more accurate hand hygiene compliance information.

This survey seeks to explore how acceptable the use of video camera technology is for the auditing and monitoring of healthcare workers' hand hygiene practices and other infection prevention and control behaviours. You have been invited to participate in this study because you are a member of Consumers Health Forum of Australia (CHF).

We would like you to complete a short, anonymous online survey comprising of three sections: a) demographics; b) using direct observation as a hand hygiene auditing method; and c) using a video-based monitoring system as a hand hygiene auditing method. It is anticipated that the survey will take 10-20 minutes to complete.

Participation in this study is completely voluntary and you do not have to take part. Your decision whether or not to participate will not affect your current or future relationship with CHF, the researchers, or anyone else at the University of Sydney and/or any other organisation. Submitting your completed survey is an indication of your consent to participate in the study. You can withdraw your responses any time before you have submitted the survey. Once you have submitted it, your responses cannot be withdrawn because they are anonymous and therefore we will not be able to tell which one is yours.

This study is being led by Professor Ramon Z. Shaban and a team of clinical and infection prevention and control researchers from the University of Sydney. Ms Katherine J. McKay is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This study has been approved by the Human Research Ethics Committee at The University of Sydney (2021/040).

For more information about the study please contact Principal Investigator Professor Ramon Z. Shaban via email: office.professor-shaban@sydney.edu.au or telephone: +61 2 8627 3117.

A copy of the Participant Information Statement for this study is available for you to review.

[Attachment: "AccVid_PIS_v2_20210617.pdf"]

By ticking the "I agree to participate" checkbox, you consent to participate in this study.

◯ I agree to participate

SECTION A: DEMOGRAPHICS

1. Have you used a healthcare service in Australia within the last 12 months?	◯ Yes ◯ No
2. How many times in the last 12 months have you accessed a healthcare service?	◯ Current in-patient ◯ Less than 5 times ◯ More than 5 times
3. Which state or territory's healthcare services do you mostly access?	◯ New South Wales ◯ Queensland ◯ Victoria ◯ Northern Territory ◯ Australian Capital Territory ◯ Western Australia ◯ South Australia ◯ Tasmania
4. What type of healthcare service did you use or visit most recently?	◯ Metropolitan public hospital ◯ Metropolitan private hospital ◯ Regional public hospital ◯ Regional private hospital ◯ Ambulatory/outpatient service ◯ Community clinic service ◯ Other (please specify below)
	_____
5. Which of the following best describes your current gender identity?	◯ Male ◯ Female ◯ Non-binary/gender fluid ◯ Prefer not to say ◯ Different identify (Please specify below)
	_____
6. What is your age in years?	_____

SECTION B: DIRECT OBSERVATION METHOD FOR HAND HYGIENE AUDITING

The current method of collecting information about hand hygiene compliance is called direct observation. It involves a trained hand hygiene auditor being present in the ward or treatment area, watching the healthcare workers providing care and observing when they clean their hands. The auditor then assesses if correct hand hygiene was performed.

7. While you were attending the healthcare facility did you, at any time, become aware that direct observation hand hygiene auditing was taking place?

- ◯ Yes
- ◯ No

8. This next table asks about how you felt or how you would feel about an auditor being present during your patient care experience. Please rate your level of agreement with the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I don't mind my care being watched by the auditor	◯	◯	◯	◯	◯
Having an auditor present would be an invasion of my privacy	◯	◯	◯	◯	◯
I would prefer the auditor to be open about their auditing and interact with me, offering information about what is going on	◯	◯	◯	◯	◯
I would be more aware of hand hygiene practice if I realised that auditing was taking place	◯	◯	◯	◯	◯
I would feel safer knowing that healthcare worker's hand hygiene practice is being audited	◯	◯	◯	◯	◯
I think that knowing that hand hygiene auditing was taking place would empower me to talk to my healthcare workers about their hand hygiene practice	◯	◯	◯	◯	◯
It is important for auditors to offer feedback and education about hand hygiene practice to the healthcare workers caring for me	◯	◯	◯	◯	◯
I think having an auditor present to watch and record hand hygiene compliance is important for patient safety	◯	◯	◯	◯	◯

I believe that healthcare workers' hand hygiene behaviours would change when they became aware auditing was taking place	○	○	○	○	○
I would worry that the auditor might make the healthcare worker feel nervous and make a mistake because they are being watched	○	○	○	○	○
I would prefer NOT to know that auditing is taking place	○	○	○	○	○

9. If hand hygiene auditing took place in your presence, how often did the auditor offer your healthcare worker feedback or education about their practice and compliance?

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always

10. Have you ever spoken to a healthcare worker looking after you about their hand hygiene practice?

- ○ Yes
- ○ No

11. Can you explain in a few words why you have or have not spoken to your healthcare worker?

_____

SECTION C: A VIDEO-BASED MONITORING SYSTEM FOR HAND HYGIENE AUDITING

As an alternative to direct observation auditing, we have established a new approach for hand hygiene auditing. This new video-based monitoring system involves a validated hand hygiene auditor reviewing a healthcare worker's hand hygiene practices via footage recorded during patient care.

Imagine this scenario taking place during your care. A healthcare worker comes to see you. They introduce themselves to you and explain that hand hygiene auditing using a video camera may occur during your admission. As such, the healthcare worker explains that, at times, your care would be recorded.

The healthcare worker shows you the cameras that have been installed around your patient care area (e.g. on the ceiling above the head of your bed). They also tell you that these cameras only turn on and start recording when a healthcare worker is directly in the camera's field of view and then turn off when the healthcare worker is not present.

You are told that a specially trained and accredited auditor will view this recorded footage and audit the healthcare workers' hand hygiene practices. This will be done in a confidential manner using de-identified video footage (e.g. faces will be blurred out). Once the auditing is complete, the footage will be permanently deleted and the information gained will be used to improve healthcare worker practice, and therefore the quality and safety of your care.

You are told that your participation is voluntary, and you can choose to not to have your care recorded and/or footage audited.

12. The following are some proposed features of the novel VMS. Please indicate whether you believe if these features are important.

	Not at all important	Not important	Neutral	Somewhat important	Very Important
Not recording audio	○	○	○	○	○
Warning light that recording is taking place	○	○	○	○	○
Audible tone when recording starts	○	○	○	○	○
Camera placed directly overhead	○	○	○	○	○
Camera place behind the head of the bed	○	○	○	○	○
Facial blurring or pixelation	○	○	○	○	○

Cameras only record when the HCW is present	○	○	○	○	○
There is the option to turn the cameras off at any time during your care	○	○	○	○	○
Patients can turn the cameras off	○	○	○	○	○
Healthcare workers can turn the cameras off	○	○	○	○	○

13. Please rate your level of agreement with the following statements relating to the novel VMS.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel that the use of a video-based monitoring system would be an invasion of patient privacy	○	○	○	○	○
I would be unhappy to have my care being recorded	○	○	○	○	○
I think that staff would be unhappy about having their practice recorded	○	○	○	○	○
The use of video-based monitoring system for auditing could cause staff to feel that they were not trusted	○	○	○	○	○
I would feel safer knowing that staff hand hygiene practice was being monitored and recorded	○	○	○	○	○
I think that I would soon forget about the cameras	○	○	○	○	○
I think that the data recorded by this method would be more accurate than that collected by direct observation	○	○	○	○	○
I am comfortable with the use of such technology to monitor hand hygiene compliance	○	○	○	○	○

14. Please rate your level of agreement with the following statements regarding how you would feel about your recorded footage being used for other purposes which are not hand hygiene-related:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Deliberate injury/assault of a patient	◯	◯	◯	◯	◯
Assault of a staff member	◯	◯	◯	◯	◯
Theft	◯	◯	◯	◯	◯
Patients or visitors tampering with medical devices	◯	◯	◯	◯	◯
Medical negligence	◯	◯	◯	◯	◯
Correct use of personal protective equipment (e.g. gloves, masks, gowns)	◯	◯	◯	◯	◯
It should only be used for auditing of hand hygiene practices	◯	◯	◯	◯	◯

15. Do you believe that patient consent is required to conduct hand hygiene auditing using novel VMS?

◯ Yes
◯ No

16. Please rate your level of agreement with the following ways to obtain patient consent:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Video recording can occur without the need to obtain individual patient consent.	◯	◯	◯	◯	◯
Signs explaining that auditing may take place and information about how to opt out should be prominently displayed in the patient room.	◯	◯	◯	◯	◯
Consent for video recording should be obtained only once and will apply to any/all future admissions.	◯	◯	◯	◯	◯
Individual consent should be obtained on every admission to the facility.	◯	◯	◯	◯	◯

17. Which is your preferred method for hand hygiene auditing in all healthcare facilities?

◯ Direct observation
◯ Novel VMS
◯ Combination of both

18. Please explain why you feel this way.

_____

19. If novel VMS were to replace direct observation, how acceptable is this method to you as a patient?

◯ Very unacceptable
◯ Unacceptable
◯ Neutral
◯ Acceptable
◯ Very acceptable

20. Do you have any other comments to make about direct observation, and/or novel VMS as a hand hygiene audit tool?	_____
If you wish to receive a brief summary of the study results, please provide your email address:	_____

Appendix Q: Phase 3: Interview Question Guide – Auditors and Frontline HCWs.

Interview Question Guide for Healthcare Workers

[Note: subject to change as a result of preliminary analysis of survey data]

Non-identifiable demographic data

1. **In which Australian state of territory do you currently or ordinarily work?**
2. **Which college/organisation that most identify with**
   Eg:
   - The Australian College of Nursing (ACN)
   - The Australasian Society of Infectious Diseases (ASID)
   - The Australasian Collage for Infection Prevention and Control (ACIPC)
3. **What is your professional area of practice?**
4. **How many years have you been practicing as a healthcare worker (HCW)**
5. **What is your primary place of work?**
   Eg:
   - Metropolitan public hospital
   - Metropolitan private hospital
   - Regional public hospital
   - Regional private hospital
   - Ambulatory/outpatient service
   - Community clinic service
     Other (please specify)
6. ***How do you describe your current gender identity?***
7. Have you had experience of direct observational (human) auditing in health care?

Description of Direct Observational Hand Hygiene Auditing: The current method of collecting information about hand hygiene compliance is called direct observation. It involves a trained hand hygiene auditor being present in the clinical area, observing HCW practice and comparing it to the WHO 5 moments framework. The overall compliance rate is calculated by dividing the number of times hand hygiene that met the 5 moment's criteria occurred, by the number of times it should have occurred.
Share screen to show video of Direct Observational auditing (if needed)

- Are you or have you been a validated Hand Hygiene Auditor?

- Why do we perform HH auditing?
    - What is the aim or the "point" of USING the method DO to collect information about hand hygiene?
    - What are we trying to achieve when we (as auditors stand there with our clip boards?

- How did you feel about having your practice audited?

- Do you think direct observation is a good method of assessing healthcare worker practice?
    - Why/why not?
    - How often do you think feedback is actually given (by you vs others)
    - How is feedback received? – well, badly,
    - Do you think it leads to real behaviour change?

- Do you feel that Do alters the way HCWs practice?
    - In what way

- Do you feel that this method is an invasion of the patient's privacy – why/why not?

Video-based monitoring system:
Video based monitoring systems would involve the placement of cameras in the patient care area (e.g. in the patient's room)
These cameras may record continuously or turn on only in the presence of a healthcare worker via a proximity tag or in response to movement or sounds.
Cameras would record HCW-patient interactions which would then be audited for hand hygiene compliance.
The following **"rules"** would apply to this auditing method.
- Patients would be informed of the auditing process and have the chance to opt out completely or intermittently.
- Footage would be retained for 48-hours and then be deleted.
- Auditing of hand hygiene compliance would be performed from the footage in a confidential manner by trained and validated hand hygiene auditors.
- Public feedback of results (eg to managers) would be reported in a de-identified manner (HCW designation and moment). Personal, confidential, 1:1 feedback would

be provided only upon request of the HCW and would be delivered in a positive and learning focused manner.

- Footage would not be utilised for any other purposes than those described, and would not be used in staff appraisal, performance review or recorded on staff files excepting in the circumstances of major critical incident. Major or critical incidents (eg, criminal activities, patient or staff assault) would trigger a review process as per normal hospital policy and procedure.

SHOW PARTICIPANT FOOTAGE SAMPLES RECORDED BY VIDEO MONITORING SYSTEMS FOR THE PURPOSES OF HAND HYGIENE AUDITING

Be sure to mention that this is proposed as part of the hybrid approach – it's not an either/or

- What is your first reaction to the idea of using video cameras to record HCW practice so that it can be audited for quality/compliance
    - Can you explain why you feel this way?
- Are you aware of the use of cameras is other aspects of daily life (eg CCTV) – how do you feel about these uses?
- What do you think would be good about this approach to hand hygiene auditing?
- What problems or issues do you see with this approach;
    - do you have any concerns about it?
    - Do you think other people would have concerns about it
- Do you think that the use of cameras would be an invasion of patient privacy?
- It is anticipated that this approach has the potential to improve patient safety through better HCW practice and hence better quality of care – does this balance/mitigate the potential for invasion of privacy?

- Is there any modification/caveats/rules/guarantees that would be needed to make this system more acceptable?
    - Suggestions have included:
        - The camera setting which means they only activate when the HCW is in the room
        - A light or other indicator that tuns on when the filming is occurring
        - The patient can turn the camera off when they want to
        - No recording of audio – is this important (why/why not)
        - Camera's positioned so that the view is from above and/or behind not face on
        - Automatic facial pixilation

- Are there any other "safety" aspects of the system that you think staff or patients would need to be accepting of the system

- If the option was available, would you like confidential. 1:1 feedback of your practice including the chance to look at the footage?

    - Imagine you are reviewing some HH footage and you see a staff member put an IV in a patient with really poor aseptic technique… how should this be handled
- OR
    - Imagine that your HH auditor has reviewed some footage which shows you putting in an IV using incorrect aseptic technique – how should this be handled?

- "Major Incidents" would trigger a "review" response
  - What kind of incidents should this include?
  - How should this "review" response/feedback be undertaken?

EG

- Confidential feedback to HCW
- Confidential feedback to HCWs manager/supervisor
- Feedback to manager/supervisor only in HCW refuses to engage
- Something else

- Are there any other "safety" aspects of the system that you think HCWs would need to be accepting of the system

- If this approach was to be used do you think consent would be required? If so, how should it be obtained?
  - E.g.
    - Standard/routine practice that occurs unless a patient says they don't want it
    - Signs advising that recording may take place
    - Verbal explanation and consent
    - Written consent

- It is anticipated that footage would be deleted rather than retained
  - Is this important?
  - Rolling deletion within 2-14 days is the usual practice – what is your opinion of this?
  - Are their any circumstances where the footage should be retained?

- Imagine that you are working on a ward where there are cameras in every patient room. They are set so that they only record when the HCW is in the room with the patient so that HH practice can be audited

Are their any circumstances where you think the cameras could/should be used for other purposes – eg the settings could be changes to continuous recording, motion detection etc

- Staff safety/assault prevention
- Falls prevention
- Suicide watch
- Telehealth
- Family conferences/video chats

- Do you have any other thoughts about this proposed approach?

Appendix R: Phase 3: Interview Guide: Patients/Consumers.

Interview Question Guide – Healthcare Consumers

[Note: subject to change as a result of preliminary analysis of survey data]

Non-identifiable demographic questions

1. Have you used a healthcare service in Australia within the last 12 months?
2. Approximately how many times in the last 12 months have you or a family member/friends accessed a healthcare service?
3. Which state or territory healthcare service do you mostly access?
4. What type of healthcare service did you or your friend/relative use or visit most recently? EG
    - Metropolitan public hospital
    - Metropolitan private hospital
    - Regional public hospital
    - Regional private hospital
    - Ambulatory/outpatient service
    - Community clinic service
    - Other
5. How do you describe your current gender identity?
6. What is your age?

Description of Direct Observational Hand Hygiene Auditing:
The current method of collecting information about hand hygiene compliance is called direct observation. It involves a trained hand hygiene auditor being present in the ward or treatment area, watching the healthcare workers providing care and indicating when they clean their hands. The auditor works out if the hand hygiene is done at the correct time to best protect the patient from infection, according to the World Health Organisation criteria. The auditor may be quite obvious, or discrete.

Share screen to show video of Direct Observational auditing

- Have you had experience of direct observational (human) auditing taking place whist you or your relative were a consumer of health care?
- (if yes) Did you receive an explanation about the process of auditing?
- How did you feel about this? (if no experience … "how do you think you would feel about this process?")
- Do you think this is a good method of assessing healthcare workers' practice?
- Why/why not?
- Do you feel that this method would change the HCWs behaviours – in what way?
- Do you feel that this method is an invasion of the patient's privacy – why/why not?

Video-based monitoring system:
Video based monitoring systems would involve the placement of cameras in the patient care area (e.g. in the patient's room)
These cameras may record continuously or turn on only in the presence of a healthcare worker via a proximity tag or in response to movement or sounds.

Cameras would record HCW-patient interactions which would then be audited for hand hygiene compliance.
The following "rules" would apply to this auditing method:

- Patients would be informed of the auditing process and have the chance to opt out completely or intermittently – that is, to have the camera turned off for the entire time or during certain care activities.
- Footage would be kept on secure hospital servers for a maximum of 48-hours and then be automatically deleted.
- Auditing of hand hygiene compliance would be performed from the footage in a confidential manner by specially trained auditors – the footage would only be viewed by the designated auditor or a member of the Infection Prevention service.
- Footage would not be utilised for any other purposes than those described, and would not be retained or released except as required by law.

Major or critical incidents (eg, criminal activities, patient or staff assault) would trigger a review process as per normal hospital policy and procedure.

SHOW SAMPLE FOOTAGE RECORDED WITH VIDEO MONITORING SYSTEMS FOR THE PURPOSE OF AUDING HAND HYGIENE PRACTICES

- What is your first reaction to this idea of using video cameras to record healthcare worker practice so that it can be audited for quality/compliance?
- Are you able to explain why you feel this way?
- Are you aware of the use of cameras is other aspects of daily life (eg CCTV) – how do you feel about these uses?

- What do you think would be good about this approach to hand hygiene auditing?
- What problems or issues do you see with this approach; do you have any concerns about it?
- Do you think that the use of cameras would be an invasion of patient privacy?
- It is anticipated that this approach has the potential to improve patient safety through better HCW practice and hence better quality of care – does this balance/mitigate the potential for invasion of privacy?

- Are there any modification/caveats/rules/guarantees that would be needed to make this system more acceptable?
    - Suggestions have included:
        - Camera's which activate only when the HCW is in the room
        - A light or other indicator that tuns on when the filming is occurring
        - The patient can turn the camera off when they want to
        - No recording of audio
        - Camera's positioned so that the view is from above and/or behind not face on
        - Automatic facial pixilation
- Are there any other "safety" aspects of the system that you think patients would need to be accepting of the system

- Are there any other "safety" aspects of the system that you think HCWs would need to be accepting of the system

- It was stated that major incidents would trigger a review as per normal hospital policy
    - What kind of things would you consider "major Incidents"
    - What should this review process involve?
- If this approach was to be used do you think consent would be required? If so, how should it be obtained?
    - E.g.
        - Standard/routine practice that occurs unless a patient says they don't want it
        - Signs advising that recording may take place
        - Verbal explanation and consent
        - Written consent

- It is anticipated that footage would be deleted within 48 hours of recording – how do you feel about this?
- The potential to use cameras for multiple purposes has been raised... how do you feel about the following:
    - Staff safety/assault prevention
    - Falls prevention
    - Suicide watch
    - Telehealth
    - Family conferences/video chats

- Do you have any other thoughts about this proposed approach?

Appendix S: Sample communication to HCW and Patient/Consumer associations regarding recruitment including email invitations to be mediated by the associations.

Dear ACN/ASID/ACIPC members,

We are conducting a study on the "*acceptability of novel video-based monitoring system for auditing and monitoring healthcare worker hand hygiene practices*".

Hand hygiene is the most important thing a healthcare worker (HCW) can do to prevent a patient from getting an infection. Auditing of HCW's hand hygiene practices is required in all public healthcare facilities in Australia.

If you are a hand hygiene auditor or if you have ever had your hand hygiene practice audited, we would love to hear your thoughts on the potential use of the novel video-based monitoring system for auditing HCWs' hand hygiene practices.

There are two components in our study:

1. Online survey (anticipated to take 20-30 minutes to complete)
2. Interview (via zoom and is anticipated to take 20-30 minutes)

You can choose to participate in either or in both. The Participant Information Sheet (PIS) for the survey and interview can be found in the links below. The PIS provides more information about the research study. Knowing what is involved will help you decide if you want to take part.

- To participate in the survey, please click here
- To participate in the interview, please click here

This study is being led by Professor Ramon Z. Shaban (Principal Investigator) and Ms Katherine J. McKay (PhD candidate) from the University of Sydney. This study has been approved by the Human Research Ethics Committee at The University of Sydney (approval number 2021/040).

If you would like more information about this study, please contact Katherine McKay at kmck4637@uni.sydney.edu.au.

Thank you.

Dear members of the Consumers Health Forum of Australia,

We are conducting a study on the "*acceptability of novel video-based monitoring system for auditing and monitoring healthcare worker hand hygiene practices*".

Hand hygiene is the most important thing a healthcare worker (HCW) can do to prevent a patient from getting an infection. Auditing of HCW's hand hygiene practices is required in all public healthcare facilities in Australia.

We would like to explore the attitudes of healthcare consumers to the potential use of the novel video-based monitoring system for auditing HCWs' hand hygiene practices. You have been invited to participate in this part of the study because you are a member of CHF.

There are two components in our study:

3. Online survey (anticipated to take 10-20 minutes to complete)
4. Interview (via zoom and is anticipated to take 20-30 minutes)

You can choose to participate in either or in both. The Participant Information Sheet (PIS) for the survey and interview can be found in the links below. The PIS provides more information about the research study. Knowing what is involved will help you decide if you want to take part.

- To participate in the survey, please click here
- To participate in the interview, please click here

This study is being led by Professor Ramon Z. Shaban (Principal Investigator) and Ms Katherine J. McKay (PhD candidate) from the University of Sydney. This study has been approved by the Human Research Ethics Committee at The University of Sydney (approval number 2021/040).

If you would like more information about this study, please contact Katherine McKay at kmck4637@uni.sydney.edu.au.

Thank you.

Appendix T: Phase 3: Human Research Ethics Committee, The University of Sydney – Phase 3: letter of Approval: Project 2021/040: June 2021.

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Wednesday, 2 June 2021

Prof Ramon Shaban
Clinical Nursing; Faculty of Medicine and Health
Email: ramon.shaban@sydney.edu.au

Dear Ramon,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.:	**2021/040**
Project Title:	**The acceptability of novel video-based monitoring system (VMS) for auditing and monitoring healthcare worker hand hygiene practices: An exploratory study**
Authorised Personnel:	**Shaban Ramon; Ferguson Patricia; Kaufman-Francis Keren; Li Cecilia Zhi-Jie; McKay Kat; Nahidi Shizar; Sotomayor Castillo Cristina Fabiola;**
Approval Period:	**02 June 2021** to **02 June 2025**
First Annual Report Due:	**02 June 2022**

Documents Approved:

Date Uploaded	Version Number	Document Name
26/03/2021	Version 2	A2_AccVid_Healthcare_consumers_recruitment_CLEAN
26/03/2021	Version 2	A9_AccVid_PIS_Survey_CLEAN
26/03/2021	Version 2	A0_AccVid_protocol_CLEAN
26/03/2021	Version 1	A1_AccVid_HCW_recruitment_CLEAN
26/03/2021	Version 2	A3_AccVid_HCW_survey
26/03/2021	Version 2	A4_AccVid_Healthcare_consumers_survey
26/03/2021	Version 2	A5_AccVid_HCW_Interview_questions_CLEAN
26/03/2021	Version 2	A6_AccVid_Healthcare_consumers_interview_questions_CLEAN
26/03/2021	Version 2	A10_AccVid_PICF_Interview_CLEAN
14/01/2021	Version 1	A7_AccVid_Technical spec for novel VMS
14/01/2021	Version 1	A8_AccVid_Interview email

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).

THE UNIVERSITY OF SYDNEY

- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Associate Professor Michael Skilton
Chair, Health Review Committee (Low Risk)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

Appendix U: Phase 3: Participant Information and Consent Form

THE UNIVERSITY OF SYDNEY

Susan Wakil School of Nursing and Midwifery
Faculty of Medicine and Health
University of Sydney

ABN 15 211 513 464

CHIEF INVESTIGATOR (SUPERVISOR)

Professor Ramon Z. Shaban
Clinical Chair of Infection Prevention and Disease Control

Office 0.4.20
Westmead Institute for Medical Research
The University of Sydney
NSW 2145 AUSTRALIA
Telephone: +61 2 8627 3117
Email: office.professor-shaban@sydney.edu.au
Web: http://www.sydney.edu.au/

The acceptability of novel video-based monitoring system (VMS) for auditing and monitoring healthcare worker hand hygiene practices: An exploratory study

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

Hand hygiene is an essential aspect of patient safety. Performing hand hygiene at the right time, in the right way and with the right products is the most important thing a healthcare worker can do to prevent a patient from getting an infection. Auditing of healthcare workers' hand hygiene practices is required in all public healthcare facilities in Australia.

To improve the efficacy and accuracy of auditing, various electronic methods have been proposed. A research team from the University of Sydney have developed a new approach to hand hygiene auditing, incorporating a novel video-based monitoring system. This new approach shows promise in terms of collecting more accurate hand hygiene compliance information.

This part of the study explores the attitudes of healthcare workers and healthcare consumers to the potential use of the novel video-based monitoring systems for auditing healthcare workers' hand hygiene practice. You have been invited to participate in this part of the study because you are a healthcare worker or a healthcare consumer.

This Participant Information Statement gives you information about the research study. Knowing what is involved will help you decide if you want to take part. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:

- Understand what you have read.
- Agree to take part in the research study as outlined below.
- Agree to the use of your personal (anonymised) information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:

Investigator	Organisation(s)
Professor Ramon Z. Shaban	The University of Sydney and Western Sydney Local Health District
Ms Katherine J. McKay	The University of Sydney
Dr Patricia E. Ferguson	The University of Sydney and Westmead Hospital
Dr Cecilia Li	The University of Sydney
Dr Keren Kaufman-Francis	The University of Sydney
Dr Shizar Nahidi	The University of Sydney
Dr Cristina Sotyomayor-Castillo	The University of Sydney

Professor Ramon Z. Shaban is the Principal Investigator for this study. Ms Katherine J. McKay is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This will take place under the supervision of Professor Ramon Z. Shaban, Dr Patricia E. Ferguson and Dr Cecilia Li.

FUNDING DECLARATION: This is an investigator-initiated study that is supported by a 2020 Seed Funding Grant from the Marie Bashir Institute for Infectious Diseases and Biosecurity.

CONFLICTS OF INTEREST: No relevant disclosures.

(3) What will the study involve for me?

You are invited to participate in a brief interview. The interview will be held, via telephone or Zoom at a time and place that is convenient for you. It is anticipated that the interview will take approximately 20 to 30 minutes.

During the interview we will discuss your thoughts and feelings about both the current method of direct human observational auditing and the novel video-based monitoring system. We are seeking to understand what you see as both the positives and negatives of such an approach, as well as things that would "make it work" and things that would "get in the way".

For the purposes of this study, this interview will be audio recorded. Recordings will be transcribed verbatim by members of the research team. Once transcribed and anonymised, the original records will be permanently erased. Should you wish to receive a copy of the interview transcript for your records, please check the box on the consent form.

(4) How much of my time will the study take?

The interview is anticipated to last approximately 20 to 30 minutes.

(5) Who can take part in the study?

Healthcare workers and healthcare consumers who are members of the following professional colleges and organisations who expressed an interest in participating in an interview following the completion of the online survey. There is no other inclusion or exclusion criteria.

No.	Professional college/organisation
1	The Australian College of Nursing (ACN)
2	The Australian Nurses & Midwives Association (ANMF)
3	Australasian College for Infection Prevention and Control (ACIPC)

4	The Royal Australasian College of Physicians (RACP)
5	Allied Health Professions Australia (AHPA)
6	Consumers Health Forum of Australia (CHF)

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney, Western Sydney Local Health District or any of the professional colleges and organisations listed in the table above.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by contacting any of the above listed researchers.

You may also refuse to answer any questions that you do not wish to answer during the interview or request that it cease at any time.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study. In the unlikely event that you experience distress or anxiety in relation to the interview, the interview will be paused or ceased, and appropriate psychological support will be provided to you.

There is no information obtained in connection with this study that can identify you. All collected information will remain confidential and will only be accessed by members of the research team. No data that identifies you will be reported in publications or presentations arising from the study.

The information you provide will only be used for the purpose of this research study, and will only be disclosed with your permission, except as required by law.

(8) Are there any benefits associated with being in the study?

We cannot guarantee that you will receive any direct benefits from being in the study. The benefits that may arise through your participation in this project are mostly altruistic in nature and may arise from knowing that you are advancing knowledge regarding how practice changes may be introduced in an effective and cost-efficient way.

(9) What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to us collecting your interview responses for the purposes of this research study.

Audio recordings of interviews will be transcribed by members of the research team. Unique identifiers will be allocated as a means of ensuring confidentiality and anonymity. All original audio recordings will be destroyed once the transcription is complete and verified.

The information you provide will be stored securely and kept strictly confidential, except as required by law. It is anticipated that the results of this research study will be published and/or presented in a variety of scientific forums. In any publication and/or presentation, information will be provided in such a way that you or your hospital cannot be identified, except with your express permission.

All data will be stored on password-protected confidential servers within the Western Sydney Local Health District and the University of Sydney, Westmead Campus in accordance with prevailing legislation policies

at both institutions. In accordance with The University of Sydney Policy, records for this study will be stored securely for five years following publication of the results before destruction.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Principal Investigator, Professor Ramon Z. Shaban and PhD researcher, Ms Katherine J. McKay, are available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact any of the researchers listed below:

Investigator	Contact details
Professor Ramon Z. Shaban	Email: office.professor-shaban@sydney.edu.au Phone: +61 2 8627 3117
Ms Katherine J. McKay	Email: kmck4637@uni.sydney.edu.au Phone: +61 404 809 496

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. This feedback will be in the form of a one-page lay summary and no personalised feedback will be provided. If you wish to receive the one-page lay summary, please tick the box on the Participant Consent Form and provide your contact details. You will receive this feedback after the study is completed.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney (to be inserted). As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007).* This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University of Sydney using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

This section of the information sheet is for you to keep.
If you would like to participate in the study, please complete the consent section below and return it to the research team.

THE UNIVERSITY OF SYDNEY

Susan Wakil School of Nursing and Midwifery
Faculty of Medicine and Health
University of Sydney

ABN 15 211 513 464

CHIEF INVESTIGATOR (SUPERVISOR)

Professor Ramon Z. Shaban
Clinical Chair of Infection Prevention and Disease Control

Office 0.4.20
Westmead Institute for Medical Research
The University of Sydney
NSW 2145 AUSTRALIA
Telephone: +61 2 8627 3117
Email: office.professor-shaban@sydney.edu.au
Web: http://www.sydney.edu.au/

The acceptability of novel video-based monitoring system (VMS) for auditing and monitoring healthcare worker hand hygiene practices: An exploratory study

PARTICIPANT CONSENT FORM

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

- I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- I have read the Participant Information Statement and that I am able to discuss my involvement in the study with the researchers if I wished to do so.
- The researchers have answered any questions that I had about the study and I am happy with the answers.
- I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers, or anyone else at the University of Sydney now or in the future.
- I understand that I can withdraw from the study at any time.
- I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.
- I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.
- I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

I consent to:

- **Audio-recording** YES ☐ NO ☐
- **Being contacted about future studies** YES ☐ NO ☐

I would like to receive a copy my interview transcript YES ☐ NO ☐

I would like to receive feedback about the overall results of this study YES ☐ NO ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

☐ Postal: _____

_____

☐ Email: _____

.....
Signature

.....
PRINT name

.....
Date

Please return this completed page via email to Katherine McKay.
You will be contacted to arrange a time for an interview

Ms Katherine J. McKay
PhD Researcher
Email: kmck4637@uni.sydney.edu.au

Appendix V: NHHI hand hygiene data collection tool.

NHHI

Hand Hygiene observation - Data collection form.

Organisation:

Depart/Ward:

Date: ____ / ____ / ________

Auditor: Session No.:

Start Time: Finish Time

Duration of Session: mins

FIVE MOMENTS FOR HAND HYGIENE

1. Before touching a patient
2. Before a procedure
3. After a procedure or body fluid exposure risk
4. After touching a patient
5. After touching a patient's surroundings

Notes

Hcw	Moment	Action	Glove	Hcw	Moment	Action	Glove	Hcw	Moment	Action	Glove
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.
	○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.		○ 1 ○ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1. Rub ☐ 2. Wash ☐ 3. Missed	○ 1. On ☐ 2. Off ☐ 3. Cont.

Total Correct Moments: **Total Moments:**

Appendix X – Summary of themes emerging from the Research

Summary of themes emerging from the Research

STUDY 1

The purpose of Direct Observation

1. *It's all about getting accurate data,*
2. *It SHOULD be all about getting accurate data* (but the direct observation method means we can't),
3. *It's all about culture or behaviour change* ('the number' doesn't matter) and
4. *It SHOULD be about culture or behaviour change* (but the drive for 'the number' gets in the way).

The Strengths of Direct observation

1. On the spot
2. Being there
   a. *Seeing other things,*
   b. *Doing other things,*
   c. *Raising the profile of hand hygiene,*
   d. *Building relationships* and
   e. *Identifying barriers.*
3. All about the patient

The Limitations of Direct Observation

1. It's just not accurate
2. It's resource intensive
3. It's associated with negative feelings about hand hygiene

The Use of VMS for Hand Hygiene Compliance

POSITIVE THEMES

1. The things you might know - collecting bigger, better data
2. The things you might see - collecting other data
3. The things you might do - potential ways of using the data
4. The time you might save - efficiency of video auditing

NEGATIVE THEMES

5. Aren't we invading the patient's privacy?
6. Big brother is watching? - staff suspicion, privacy and fear of punishment
7. Will I end up on Facebook? - data storage and security
8. Are we going to get sued? - legal issues, consent and litigation?
9. You don't trust us? - damage to relationships
10. What about feedback?

STUDY 3

Acceptability of VMS for Hand Hygiene Compliance

1. Protecting Patient Privacy
2. Making Healthcare Workers Feel Safe
   a. Fear of surveillance
   b. Fear of making a mistake
   c. Fear of embarrassment
   d. Fear of punitive consequences
   e. Fear of legal consequences
3. Open Communication
   a. Consent
   b. Clarity of footage retention
   c. Confidentiality
   d. Legality and legal issues
   e. Information and education

4. The How and Where of Feedback
    a. Loss of immediate feedback
    b. Contextual feedback with VMS data
    c. Quality of feedback
5. Better Data, Better Feedback, Better Care
    a. Validity and reliability of the data collected
    b. Time efficiency of reviewing the data
    c. Rich and contextual data