Future Systems of Measurement for Hand Hygiene in Healthcare

by

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Declaration and Inclusion of Material from a Prior Thesis

The author declares that all the work contained within this thesis is her own work and has not been used previously.

All the research was undertaken independently at WMG, University of Warwick, including a period based within the Institute of Digital Healthcare (2011-2013). The design, development, conduct, analysis and interpretation of the research was carried out by the author, with no other data sources incorporated.

This thesis has not been submitted for a degree at any other university.

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Abstract

Hand hygiene is considered a key infection prevention strategy against the challenge of healthcare associated infections, as it prevents cross-transmission of microorganisms which may cause harm. Despite this, compliance amongst healthcare professionals is often poor. Considerable attention has been placed on developing interventions to increase hand hygiene, however known problems with measurement make determining improvement from established baselines difficult.

This thesis addresses measurement through three research themes: The importance of meaningful data (Study 1), the potential for technology (Study 2), and the influence of human behaviour (Study 3). These are considered in relation to guidelines developed by the World Health Organisation (WHO) (*My 5 Moments for Hand Hygiene*). The thesis output provides recommendations for the healthcare setting, technology industry and research community by forming a new conceptual and integrated way of considering the measurement of hand hygiene compliance.

A mixed methods approach was applied using a single case study methodology comprising three studies (two qualitative, one quantitative), based at a UK acute National Health Service Trust. Healthcare professionals involved in the current hand hygiene measurement process participated in all three studies (N=47). Methods included structured literature reviews, participant observation, one-to-one and group interviews, nonparticipant observation and analysis of existing case study site data.

In Study 1 healthcare professionals identified a lack of clarity regarding feedback, and a lack of synergy between hand hygiene training and measurement. Combined with data accuracy flaws, their view was that the current hand hygiene measurement process produced meaningless data.

Study 2 investigated healthcare professional views regarding the potential of technology to measure hand hygiene. It found that whilst current innovations are unable to detect all the WHO 5 Moments, healthcare professionals are interested in their potential to aid measurement and compliance. However they raised concerns about Fit for Purpose, anonymity and resistance, and over-reliance on technology and habituation. Interestingly participants suggested that hand hygiene across all WHO 5 Moments is not equal, expecting higher levels of adherence to Moments 2 and 3 than Moments 1, 4 and 5. Study 3 explored this, investigating the theory of Inherent and Elective hand hygiene behaviour. Inherent can be linked to Moments 2 and 3, through activities likely to stimulate an automatic “disgust” reaction within humans. Hand hygiene was significantly lower when healthcare professionals performed Elective rather than Inherent activities.

The research developed Inherent and Elective theory further by proposing it as a lens with which to view the WHO 5 Moments and develop strategies for improved compliance. Understanding that hand hygiene is less likely at Elective activities, linked to Moments 1, 4 and 5 suggests these as key areas of focus for technology development. Acknowledging that hand hygiene may be more instinctive at Moment 2 and 3 may be useful when planning education, leading to reduced healthcare professional apathy towards hand hygiene.

Involvement of healthcare professionals in exploring measurement processes and developing technologies for hand hygiene is proposed as key to ensure data produced by future methods of measurement is meaningful, vital to ensure desired behaviour change.

Abbreviations

Abbreviation	Full term used within presented work
ABHR	Alcohol Based Hand Rubs
API	Audit Process Involvement
APIC	Association for Professionals in Infection Control and Epidemiology
AS	Additional Source
BSI	Blood Stream Infection
CDC	Centers for Disease Control and Prevention
CDI	*Clostridium difficile* infection
CFU	Colony Forming Units
CI	Continuous Improvement
CQI	Continuous Quality Improvement
CR-BSI	Catheter Related Bloodstream Infection
CVC	Central Venous Catheter
CYHC	Cleanyourhands Campaign
ENT	Ear Nose and Throat
FFP	Fit For Purpose
GI	Gastrointestinal
GoD	Generators of Data
HAI	Hospital Acquired Infections
HAI	Handwashing Assessment Inventory
HCAI	Healthcare Associated Infections
HHO	Hand Hygiene Opportunities
HNS	Head and Neck Surgical ward
HOI	Handwashing Observation Instrument
HPS	Health Protection Scotland
ICU	Intensive Care Unit
IPC	Infection Prevention and Control
IPCT	Infection Prevention and Control Team
ITS	Interrupted Time Series
KPI	Key Performance Indicator
LHBCs	Local Health Board Co-ordinators
MICU	Medical Intensive Care Unit
MRSA	Methicillin-resistant *Staphylococcus aureus*
NHS	National Health Service
NI	Nosocomial Infections
NICU	Neonatal Intensive Care Unit
P.aeruginosa	*Pseudomonas aeruginosa*
PDSA/PDCA	Plan, Do, Study, Act/Plan, Do, Check, Act
PPE	Personal Protective Equipment
QI	Quality Improvement
QIT	Quality Improvement Team
QM	Quality Management
RCT	Randomised Control Trial
RFID	Radio Frequency Identification
RoF	Recipients of Feedback
S. aureus	*Staphylococcus aureus*
S. marcescens	*Serratia marcescens*
SICU	Surgical Intensive Care Unit
SoO	Subjects of Observation

SPC	Statistical Process Control
spp.	Species
SQC	Statistical Quality Control
SSI	Surgical Site Infection
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TQM	Total Quality Management
UHCW	University Hospitals Coventry and Warwickshire
UTI	Urinary Tract Infection
UV	Ultra Violet
VRE	Vancomycin-resistant *Enterococcus*
VREF	Vancomycin-resistant *Enterococcus Faecium*

Glossary

Colonisation: Micro-organisims are present. When this occurs on a body, they have not invaded tissue, and have not triggered a defence reaction.

Elective Hand Hygiene: Hand hygiene that is not Inherent, therefore has to be explicitly learnt and consciously invoked, and is more likely to be vulnerable to interference such as workload and time constraints.[1]

Handwashing: Term used by Whitby et al. (2006, 2007) in original Inherent and Elective work. To avoid confusion, where "washing" may imply the need for soap and water over alcohol based hand rub, the term hand hygiene is used throughout this work to refer to all types of hand decontamination.

Hand Hygiene: Term used throughout this written work to imply any form of hand decontamination, either with soap and water or with alcohol based hand rub, the efficacy and suitability of such measures being discussed herein.

Infection: Micro-organisms have invaded tissue, leading to defence reaction (e.g. inflammation). [2]

Inherent Hand Hygiene: Hand hygiene that occurs on a more automatic level, occurring when hands physically dirty or an emotional trigger has been activated. Less likely to be vulnerable to interference e.g. workload, time constraints.

Use of a, b, c….z suffixes to distinguish quotations: Where more than one quotation from a participant group (GoD, RoF, SoO, AS) has been used to illustrate a theme, an alphabetised suffix is employed to note a change in source (i.e. quote from a different participant). To increase anonymity the use of an alphabetised suffix bears no relation to an individual participant, therefore quotes attributed to (e.g.) *GoD a* in one section may not be from the same participant as those attributed to *GoD a* in another section.

Use of >> to denote conversational quotes: Where quotes from more than one person are included to illustrate a theme the expression ">>" is used to indicate the beginning of each subsequent contributor. The quotes from each of these contributors are also slightly inset from the original quote

Word Count: 69,742

[1] Inherent and Elective Hand Hygiene theory comes from Whitby et al. (2006)
[2] Distinction between Colonisation and Infection comes from Sax et al. (2007)

Chapter 1

Introduction

1. Thesis Introduction

This chapter presents an overview of the research context, and describes the motivation for addressing the research question. This context, of Healthcare Associated Infections (HCAI), is defined and quantified in terms of prevalence and burden. Factors contributing to HCAI are discussed as well as strategies designed to counter them. Also presented is an outline of the scope of this thesis: exploring future systems of measurement for hand hygiene in healthcare.

1.1. Defining Healthcare Associated Infections

> *Healthcare associated infections (HCAIs) are infections acquired as a result of contact with the healthcare system in its widest sense – from care provided in the home, to primary care, nursing home care and acute care in hospitals*.
>
> (Department of Health, 2003, in BMA, 2006, pp. 2)

Within the field of HCAI a number of labels refer to the same phenomenon. The Department of Health (DoH) definition cited here (above) provides a succinct example of a modern interpretation. The British Medical Association (BMA, 2006) use this definition to add context to their standpoint, that infections from both hospitals and the community must be considered under the HCAI banner.

Often the labels Hospital Acquired Infections (HAI) and Nosocomial Infections (NI) are used to denote the same or similar type of illness affecting Patients receiving care from healthcare settings. In 2000 the National Audit Office (NAO), in their report investigating the management and control of HAI in acute NHS Trusts in England, defined HAI as ….*infections that are neither present nor incubating when a patient enters hospital* (pp. 1).

In 2002 the World Health Organisation (WHO) responded to the growing problem of such infections by publishing their cornerstone document, "Prevention of hospital-acquired infections: A practical guide (2nd Edition)" (Ducel et al., 2002). A focus on the acute setting was highlighted by the interchanging use of the terms HAI and NI. The document outlined the prevalence of the problem and proposed factors attributable to NI development. In their definition they explicitly refer to the interchangeability of NI and HAI, and the acute setting focus:

> *Nosocomial Infections, also called 'hospital-acquired infections', are infections acquired during hospital care which are not present or incubating at admission.* (Ducel et al., 2002, pp. 4)

Thus, it is necessary to be aware that literature within the HCAI field may equally use the terms HAI or NI when referring to the same issues, contributory and resultant factors. There is, however, an increasing shift towards understanding the importance of the wider healthcare setting, and consequently the wider adoption of the HCAI label.

HCAI can originate either from sources external to the Patient's system (exogenous) or within the Patient's system (endogenous) (WHO, 2002; Ventilator-Associated Pneumonia, Safdar et al., 2005; *Clostridium difficile* infection [CDI], Tabaqchali and Jumaa, 1995). The goal of infection prevention and control (IPC) is arguably, therefore, two-fold. Firstly, to reduce the risk to Patients of developing endogenous infections, through strategies such as responsible antimicrobial management. Secondly, to reduce the potential for acquiring HCAI exogenously, through strategies focused around removing cross-transmission risk. The concept is that whilst some HCAI may be unavoidable

(Pratt et al., 2001), sound working practices should enable the goal of prevention to be reached in ever more cases:

> *Our vision is that no person is harmed by a preventable infection.*
>
> Infection Prevention Society Mission Statement (IPS, 2011a, pp. 5)

1.2. Prevalence and Burden of HCAI

Problems regarding surveillance of HCAI are being increasingly recognised (WHO, 2011). At the current time there remains no confirmed data on the total number of HCAI in England, except that issued from Point Prevalence studies (for example HPA et al., 2012). Issues regarding diagnostic criterion (Lu 2011, WHO, 2011) and mandatory reporting (DOH, 2010) contribute to lack of clarity in establishing baseline HCAI figures. This applies not just in England, but globally:

> *…reliable estimates of the global burden are hampered by a paucity of data adequately describing endemic infections at national and regional levels.*
>
> (WHO, 2011, pp. 228)

However, in 2010 the DoH accepted mandatory surveillance may not be viable:

> *It would be inappropriate to make surveillance of all HCAIs mandatory because the burden of data collection would not be justified against the potential benefits of the surveillance for patients and the entire healthcare system.* (pp. 26)

In spite of these documented problems with surveillance, the burden of HCAI has not gone unnoticed. In consecutive publications the NAO voiced concerns about both the management and control of HCAI (National Audit Office, 2000, 2004). A further publication concluded that whilst work in HCAI reduction had been made, this progress had been patchy, including a *distinct lack of urgency on issues*

such as cleanliness and compliance with good hand hygiene (House of Commons, 2005, pp. 3).

Three major surveillance studies were carried out including England in the period 1996 to 2006, their findings summarised in Figure 1-1.

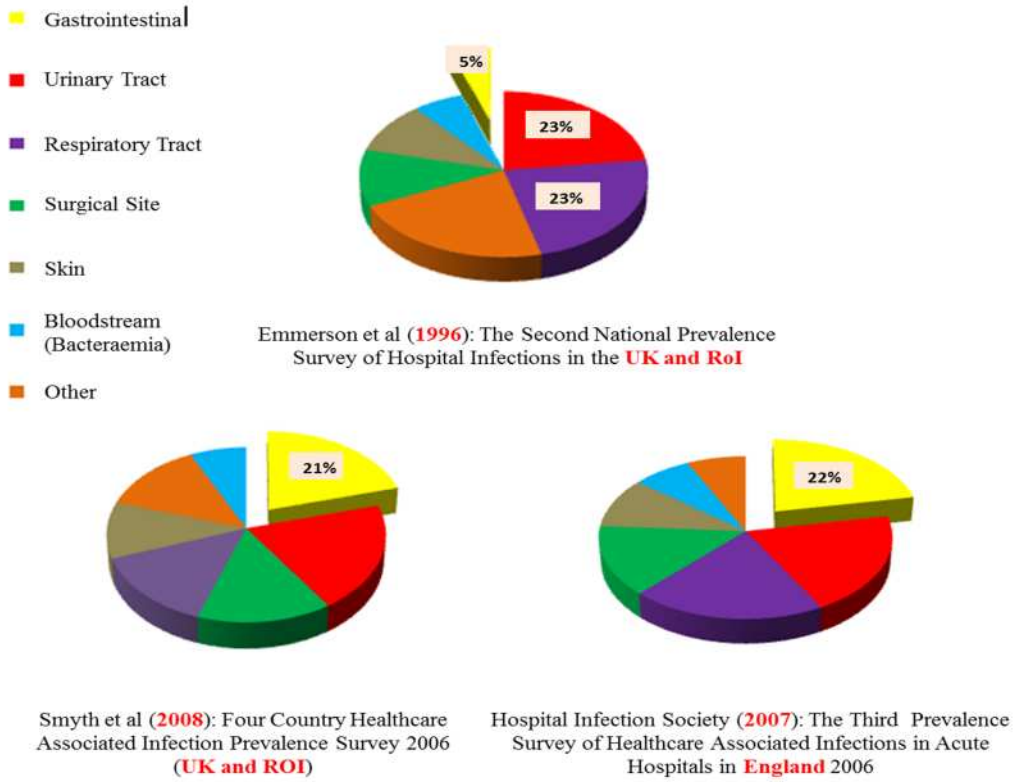


Figure 1-1: Three surveillance studies of HCAI during 1996-2006 showing rapid rise of Gastrointestinal Infections

These show a rapid rise in the dominance of Gastrointestinal Infections (GI).This was chiefly attributable to a steep rise in cases of CDI, with the Hospital Infection Society study finding 70% of the recorded GI identifiable as such (HIS, 2007).

In their four Country Surveillance study, covering Republic of Ireland (ROI), Northern Ireland (NI), England, and Wales, Smyth et al. (2008) surveyed a total of 75,694 Patients. They found that 5,743 had one or more HCAI, a percentage prevalence rate of 7.59%. Their study also revealed that the highest HCAI

prevalence could be found in high dependency areas such as Critical Care (23.23%). Specific HCAI (CDI and MRSA - Methicillin-resistant *Staphylococcus aureus*) were also at their highest in Critical Care medical units. Such findings, whilst alarming, are not surprising, bearing in mind the particular vulnerabilities of those Patients liable to be found in such units.

In 2011 England, Wales and Scotland undertook a Point Prevalence survey (Table 1-1), carried out by the Health Protection Agency (HPA et al., 2012)[3].

Table 1-1: England, Wales and Scotland HCAI Point Prevalence as reported by the HPA et al. (2012) (*reproduced from HPA et al., 2012 material*)

Table 1: Comparison of key HCAI measures in England, Scotland, Wales, 2011*			
	England	**Scotland**	**Wales**
Inclusion criteria	**Acute hospitals** Included independent sector No non-acute sector Self-selection, voluntary, 60% uptake	**All acute hospitals** Sample independent sector Included non-acute sector	**All acute hospitals** Included all non-acute sector No independent sector
Number surveyed (figures relate to acute sector only)	52443	11604	6588
HCAI prevalence from 2011 PPS	6.4% (95% CI 4.7-8.7)	4.9% (95% CI 4.5-5.4)	4.3% (95% CI 3.8-4.8)
HCAI prevalence from 2006 PPS	8.2%	9.5%	6.4%
Percentage reduction since 2006 survey	22%	51.6%**	33%
Prevalence of CDI	0.4%	0.3%	0.5%
Prevalence of MRSA Infection	<0.1%	0.2%	0.1%
Top five HCAI:			
1	Pneumonia/RTI (22.8)	UTI (22.6)	SSI (23.7)
2	UTI (17.2)	SSI (18.6)	UTI (12.3)
3	SSI (15.7)	Pneumonia (17.5)	Pneumonia (12.3)
4	Clinical Sepsis (10.5)	BSI (10.8)	GI infection (11.7)
5	BSI (8.8)	Eye & ENT (9.2)	BSI (11.0)

*Note: data relates to acute sector only, although scope of survey included under each country

**HCAI definition in Scotland different to England and Wales definition in 2006. All countries used same definition in 2011.

[3]Collaborating agencies British Infection Association (BIA), British Society for Antimicrobial Chemotherapy (BSAC), Infection Prevention Society (IPS) and Healthcare Infection Society (HIS).

This snap shot view of HCAI prevalence within the three countries demonstrated a stark contrast with that of the picture posted in 2007. GI was no longer prominent in any of the nations' top three recorded HCAI. The limitations of Point Prevalence include intragroup bias (Lanini et al., 2009), seasonal variation (Public Health Wales NHS Trust, 2011), and the impact of Patient caseload fluctuations on HCAI categories. Accepting these, the reduction in MRSA and CDI cases still suggests a positive impact of high levels of focus since 2007.

The NAO (2009) reported that in 2007 just fewer than 10,000 people in England had CDI or MRSA infections mentioned on their death certificates, as either an underlying cause (7,916) or contributory factor (1,517). The figures provided for 2007 by the ONS (Office for National Statistics, 2008) show a slight difference, due to the inclusion of data from Wales: 8,324 and 2,052respectively, totalling just over 10,000.

By 2011, however, dramatic falls for both infections were being recorded (Office of National Statistics, 2013a, b). Mentions for MRSA fell to 364, and for CDI the figure fell to2,053. This represented a 77% and 75% fall respectively for the infections being mentioned on death certificates in England and Wales. The latest figures were released in August 2013.There were 292 deaths involving MRSA recorded, and 1,646 deaths involving CDI, both representing a 20% improvement (Office of National Statistics2013a, 2013b).

In their formal Strategy, the Infection Prevention Society (IPS) presents the European picture thus:

> *According to data from across Europe over 4 million people are affected by HAI every year. Of these 4 million, HAIs play a direct or indirect role in the deaths of just under 150,000 people.*(2011a, pp. 4)

Continuing on an international front, a point prevalence study of Canada carried out in 2002 found an HCAI rate within Patients of 10.5%(Gravel et al., 2007). In America, Klevens et al. (2007) gave the 2002 picture as:

> *In 2002, the estimated number of HAIs in U.S. hospitals, adjusted to include federal facilities, was approximately 1.7 million…estimated deaths associated with HAIs in U.S. hospitals were 98,987.*(pp. 160)

Finally, the figures from the 2002 WHO cornerstone document report the global picture as follows:

> *A prevalence survey conducted under the auspices of WHO in 55 hospitals of 14 countries representing 4 WHO Regions (Europe, Eastern Mediterranean, South-East Asia and Western Pacific) showed an average of 8.7% of hospital patients had nosocomial infections. At any time, over 1.4 million people worldwide suffer from infectious complications acquired in hospital.*
>
> (Ducel et al., 2002, pp. 1)

Moving back towards a UK focus it is possible to locate estimations of the economic burden posed to the NHS by HCAI. Using a House of Commons report (House of Commons, 2005) the DoH confirmed that 300,000 was the best estimate of the annual number of HCAI. Since 1999 the widely accepted estimated cost to NHS hospitals of caring for people that acquire a HCAI is over £1 billion a year (Plowman et al., 1999). Split a different way the Plowman et al. report attributes an additional average cost of £3,154 per Patient should they acquire a HCAI during their in-Patient treatment.

The burden of HCAI, though, is not merely economic. Patients contracting a HCAI can experience additional pain, treatment and even death. This is alongside the psychological burden of anxiety caused to both them and their families (Ducel et al., 2002). The NAO summed up such considerations in 2000:

> *Their effects vary from discomfort for the patient to prolonged or permanent disability and a small proportion of patient deaths each year are primarily attributable to hospital acquired infections.*(pp.1)

Work on Surgical Site Infections (SSI) provides a deeper insight into the effect of HCAI on the Patient, allowing consideration over and above the economic burden. Tanner et al. (2013) interviewed Patients known by their hospitals to have recently experienced an SSI. Thematic analysis revealed that Patients lacked an awareness of SSI, in some cases having received treatment (antibiotics) without realising this was not routine. They were also likely to look for explanations to assume responsibility for the SSI occurring. The individual economic burden was also revealed. Patients outlined the significant costs their SSI had caused, including loss of both personal and other family member earnings as additional care was required to deal with the impact of their infection. The additional psychological stress this may cause can be inferred. Further details, presented at conference by Tanner (2013) provide moving support for the impact of a HCAI on Patient lives. Direct quotes from Patients interviewed for her research included: *I can't cope, I can't cope. I just can't do this; I was in utter despair;* and the strikingly pertinent: *There was a stage when I just wanted to die.*

Due to these economic and Patient implications, and the likely rises in vulnerable Patient populations, much research has been focused on identifying contributory factors to HCAI. This research allows effective IPC strategies to be devised.

1.3. Contributory Factors to HCAI

Due to advances in healthcare many varied groups of Patients are now vulnerable to HCAI, as life is preserved where previously unable. The very young and elderly, and with those suffering from multiple and complex illnesses, are all likely to possess compromised immune systems. They may also have greater need for assistance from in-dwelling devices and/or antimicrobial medication. Such vulnerability has been widely reported, including by the WHO (Ducel et al., 2002) and the DOH (2003) who proposed factors leading to the increase in HCAI (Figure 1-2), (Figure 1-3).

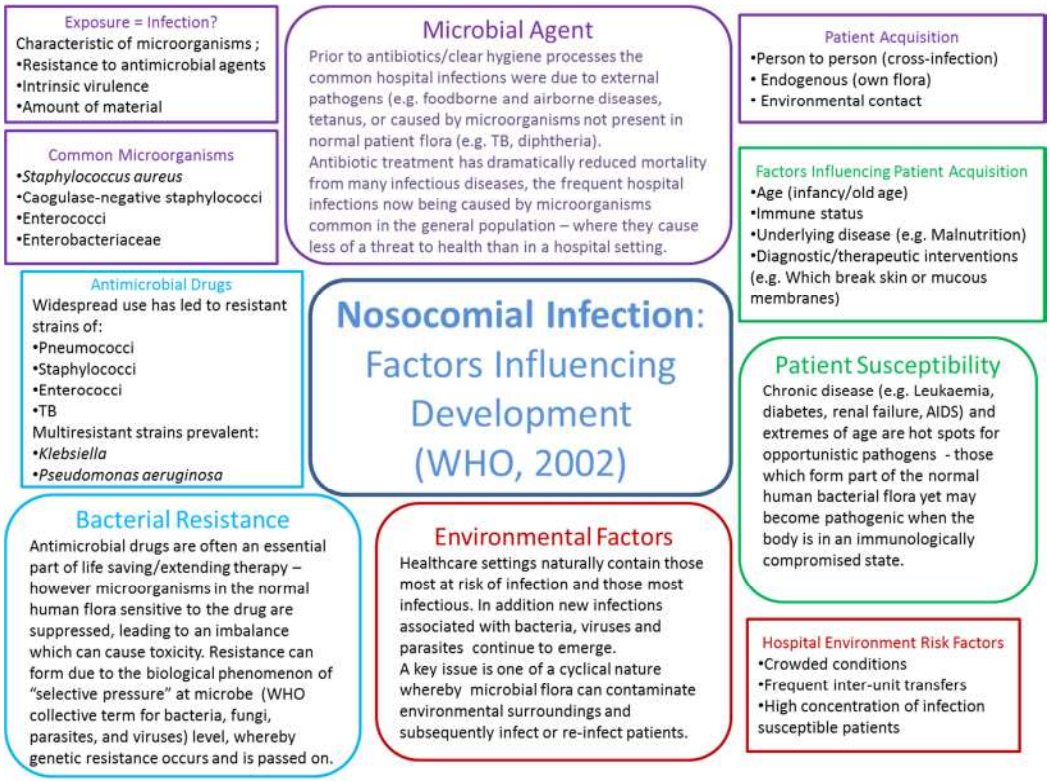


Figure 1-2: Summary of WHO (Ducel et al., 2002) discussion of factors influencing NI (now HCAI) development, from four chief categories: Microbial Agent, Patient Susceptibility, Environmental Factors and Bacterial Resistance

Four key areas proposed by the WHO (Figure 1-2) are Microbial Agent, Patient Susceptibility, Environmental Factors and Bacterial Resistance. In the figure these areas are colour-coded to related risk-factors. This shows that within each category there are further factors which increase the risk of the development of a HCAI. For example, the green category shows Patient Susceptibility and Age of the Patient.

Further contributing factors to increasing occurrences of HCAI are outlined by the DoH (Figure 1-3). These include three of the four key areas from the WHO document, here to be found within the categories Organisational (*Environmental Factors*), Antibiotic Resistance (*Bacterial Resistance*), and Patients (*Patient Susceptibility*).

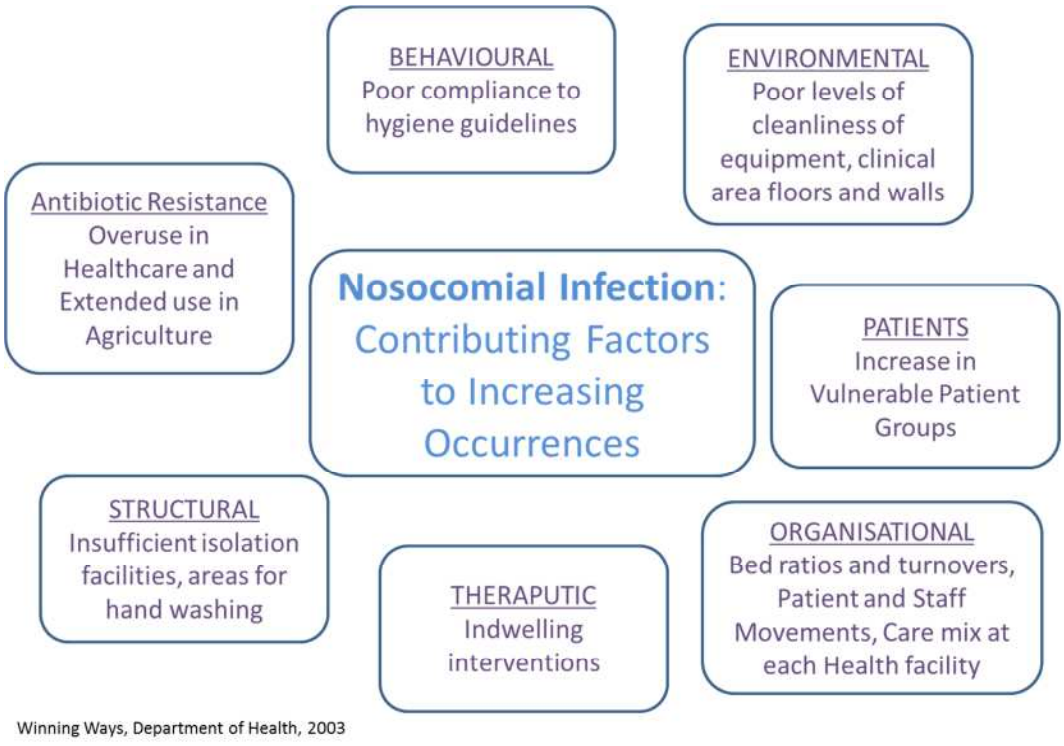


Figure 1-3: Summarising Factors proposed by Department of Health (2003) contributing to increasing cases of NI (now HCAI)
(*Taken from original statement located on pp. 7*)

Not covered is the area of Microbial Agent, however the report does make the related statement that:

> *For a person to be infected whilst they are in hospital, an essentially simple process has to operate. There has to be a source or reservoir of the bacteria, virus or other organism that can cause the infection and there has to be a vector or means of transmission.* (Department of Health, 2003, pp. 8)

New HCAI strains with increasing antimicrobial resistance (e.g. Endemic Hypervirulent 027CDI, Kontra, 2011) point towards a continuing and increasing burden upon ever stretched health resources. Of particular concern is the rise in elderly Patients within acute care. The Royal College of Physicians (2012) report that close to two thirds of all admissions are Patients aged 65+. Once the age bracket moves to 85+ the vulnerability for HCAI is further exacerbated. This cohort is likely to spend around eight days longer in hospital than those aged <65: stays of eleven days compared to three days. Length of stay has been independently shown to be a risk factor for acquisition of HCAI (e.g. for UTI [Urinary Tract Infection] in Intensive Care Units [ICU], Laupland et al., 2002). This can naturally lead to a longer stay, further increasing the risk of multiple HCAI (Paillaud et al., 2005). In their study, focusing on the role of under nutrition in HCAI, Paillaud et al. found elderly Patients (aged >70) with more than one infection stayed in hospital twice as long as those presenting with no or one infection.

Thus whilst the results from the previous wave of HCAI interventions (2007-2011) appear to show strategies were winning (i.e. Table 1-1), considerations such as the increasing vulnerability of populations indicate that the battle is not over.

1.4. The Chain of Infection

Using the Chain of Infection (Damani, 2003, Figure 1-4), the sequential steps required for infection generation, transmission and acquisition can clearly be seen. The metaphor of the chain allows for infection prevention strategies to be targeted at one (or more) of the links within the chain. Breaking the chain at any one point makes continuation of infection impossible.

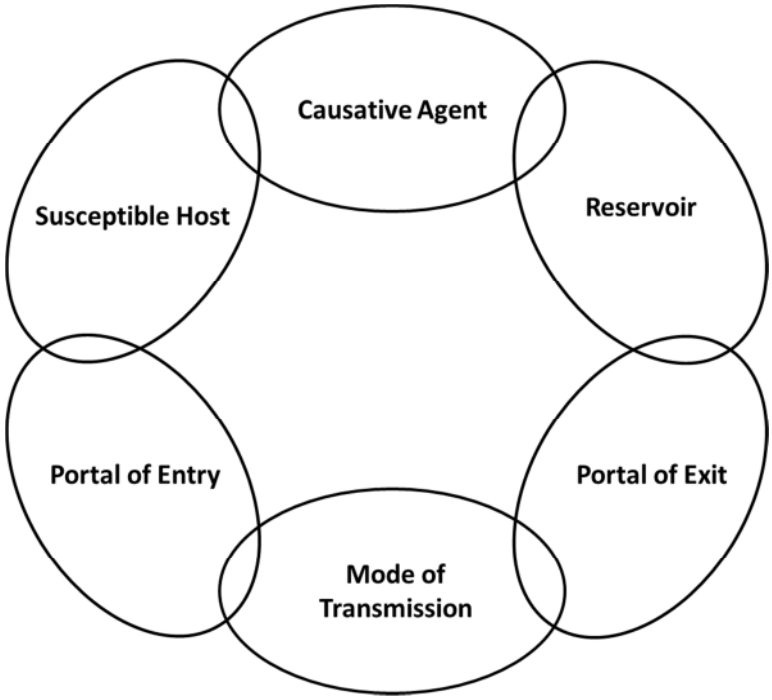


Figure 1-4: Chain of Infection (here from Damani, 2003) illustrating required sequence of events for successful infection process

For HCAI the "Causative Agent" can be seen as the microbiological agent, exogenous or endogenous. The "Portals of Exit or Entry" can be linked to therapeutic interventions (e.g. cannula use), as well as issues relating to potential infection via cross-contamination stemming from poor hand hygiene. This can be exacerbated by symptoms of specific HCAI (e.g. fecal-oral route, linked with CDI and Norovirus). Finally the "Susceptible Host" relates strongly to the vulnerable Patient population, already discussed here as a cohort on the rise.

Chapter 2 covers "Mode of Transmission" and "Reservoir" in more detail, with specific relation to hand hygiene, seeing hands as vectors for transmission, and the environment as a reservoir for potential cross-contamination.

1.5. Strategies to Counter HCAI

Crucially, an awareness of risk factors relating to the occurrence of HCAI is key to planning the most effective strategies to combat their rise. This is especially important when acknowledging the increasing vulnerability of populations engaging with healthcare services. The BMA (2006) clarifies the position succulently: *Although HCAIs cannot be eliminated, it is widely accepted that a significant proportion are avoidable as they result from cross-infection.* (pp. 8)

Strategies to counter HCAI naturally work alongside the factors proposed for their occurrence (Figure 1-2; Figure 1-3). The WHO 2002 cornerstone document (Ducel et al., 2002) provides detailed coverage on how to conduct IPC procedures, covering both every day and outbreak scenarios. Special attention is also given to environmental planning and antimicrobial use, to allow those working within the field to develop processes and practices which can incorporate good infection prevention standards.

In the UK the Epic Project (Pratt et al., 2001; Pratt et al., 2007) has twice led to national evidence-based sets of guidelines published. These enabled hospital practitioners to seek clarification and direction as to how best prevent infection in their healthcare settings. Topics including hand hygiene, catheter care and sharps disposal were all reviewed. Overviews of existing problems were offered, and

guidance as to how to proceed in the future, based on current presented evidence were presented.

Sax et al. (2009) argue that of the resultant plans devised in response to these factors, hand hygiene is of utmost significance as …*the single most important element of strategies to prevent health care–associated infection* … (pp. 827). This claim is also supported by the BMA (2006), who state that effective hand hygiene is *paramount and the single most important intervention in infection control* (pp. 9).However, despite empirically supported successfully developed models to improve hand hygiene within healthcare settings (Geneva Hand Hygiene Model, Pittet et al., 2000; WHO Multimodal Hand Hygiene improvement strategy, Sax et al., 2009) sustained healthcare professional compliance has proven difficult to obtain.

This thesis explores the role of hand hygiene as a preventative measure for HCAI from the perspective of monitoring, measurement and feedback. The standpoint held is that to evaluate interventions designed to improve one of the *most crucial interventions in the prevention of cross-infection* (Damani, 2003, pp.227), first accurate baseline measures need to be available for analysis. Such measures continue to be elusive (WHO, 2009).

1.6. Research Scope

The presented research begins from the premise that hand hygiene is a practice fundamental to IPC, required to maintain and advance strategies to reduce HCAI. The research addresses how hand hygiene is measured (the audit process), and questions whether there is a potential for technology within this process, bearing

in mind the influences of human behaviour. It explores the challenges faced by staff in performing auditing, which elements of hand hygiene may be more automatic than others, and whether any technologies could help enhance the ability to both perform and audit hand hygiene when necessary. Whilst discussed in more depth in the forthcoming literature review chapters, the next sections outline the chief building blocks providing the background to the current research.

1.6.1. Domain Knowledge

The concept of domain knowledge is central to the current research. It recognises that individuals experiencing a process are liable to possess tacit awareness and understanding of regulations (Hovenga et al., 2005), which can be seen as a valuable information source. The identification of those within the process is seen as vital to ensuring that any representation of the process is valid, and possesses meaning for those who experience it.

1.6.2. The Role of Hand Hygiene

Hand hygiene has been identified as a key tool in reducing HCAI cross-transmission (WHO, 2009). Empirical evidence for the role of healthcare professional hands in the transmission of pathogenic bacteria includes Bauer et al. (1990), Pittet et al. (1999), Pessoa-Silva et al. (2004), and Creamer et al. (2010). All performed in-situ studies to monitor levels of contamination on healthcare professional hand surfaces, and the potential for this to spread both to and from Patients and the surrounding environment. Direct evidence for the role of healthcare professional hands in HCAI outbreaks includes El Shafie et al. (2003) and Zawacki et al. (2004).

1.6.3. Standards for Hand Hygiene

Global interventions such as the WHO's *My 5 Moments for Hand Hygiene* and national campaigns including the *Cleanyourhands* Campaign (CYHC) are testament to the level of attention hand hygiene receives (Sax et al., 2007, 2009; National Patient Safety Agency, 2004). The WHO strongly promotes the 5 Moments approach as an *evidence based, field-tested, user-centred approach designed to be easy to learn, logical and applicable in a wide range of settings* (WHO, 2013). Recent findings support its successful implementation in a range of global settings (Allegranzi et al., 2013).

Despite such evidence-based guidelines, research also stands testament to problems obtaining and monitoring hand hygiene compliance to required levels (Kohli et al., 2009). In 2009 the WHO summarised the wealth of hand hygiene adherence research carried out over the past 35 years (1977 onwards). This demonstrated vast fluctuations between healthcare professional compliance rates (from 5% to 89%, Berg et al., 1995 and Raskind et al., 2007 respectively, resultant average of 38.7%). It is important to note that any cross-comparison between studies is difficult, due to methodological differences and mixed hand hygiene requirements across settings. However, the picture presented shows that hand hygiene compliance, in all the measured healthcare settings, fell lower than the standards set by guidelines implemented at the time of the research.

1.6.4. Measurement of Hand Hygiene

When contemplating any improvement strategy, reliable, valid measurement is a crucial tool in monitoring progress. Prior to implementing strategies to improve

hand hygiene compliance, first the current performance level must be established, to assess the impact of any intervention. Yet such behaviour has proven difficult to accurately measure (Haas and Larson, 2007). Within this thesis the terms "monitoring", "measurement" and "feedback" are used to outline the elements required to accurately assess interventions. A successful process needs to monitor hand hygiene by detecting it has been required, and measure the details of the event to record whether decontamination occurred. It must also provide feedback to allow analysis and focus on subsequent priorities for performance change.

Auditing, a standard measurement procedure from the Quality Management (QM) approach, has been widely adopted as a method of data collection within healthcare hand hygiene assessment (Kilpatrick, 2008). This includes the development of a tool specifically designed to allow observation and measurement of performance at the WHO 5 Moments (Hand Hygiene Observation Tools, WHO, 2009b). However, even such tools which use direct observation, deemed the gold standard by the WHO, only offer snap shots of hand hygiene. They may also provoke the highlighted Hawthorne effect (Kohli et al., 2009). Scope thus remains for alternative methods of measurement.

1.6.5. The Potential Role of Technology

Technology has been trialled in other sectors to ensure worker compliance to essential cleanliness protocols, for example the food industry (Rubinstein, 1998) and the space industry (Garner, 2008). Aims have been to reduce labour intensive aspects of ensuring compliance and addressing the potentially flawed method of direct observation. In healthcare settings specific work has been undertaken within the area of hand hygiene (Swoboda et al., 2004; Boscart et al., 2008;

Venkatesh et al., 2008). There is, however, a lack of evidence that the concept of domain knowledge has been considered. This relates to ensuring that the tacit awareness and understanding of those involved in the process being investigated has been considered to ensure that the product is Fit For Purpose. Such involvement of the proposed end users can result in perceptions of increased usefulness and perceived ease of use. These perceptions can be from those involved in an innovations' development, and those made aware that it was developed involving peers from their expert area (i.e. other healthcare professionals) (Li and Calantone, 1998; Davis, 1986).

1.6.6. Human Behaviour

With relation to the mechanisms underpinning hand hygiene, findings from behavioural research suggest that different instances of hand hygiene may be triggered in separate ways. Indeed, Whitby et al. (2006, 2007) postulate two forms of hand hygiene behaviour, Inherent and Elective.

Inherent hand hygiene is an instinctive need driven by themes of self-protection. It links to decontamination at times when the hands are visibly dirty, contaminated for example by blood, or after touching an emotionally dirty area such as a Patient's groin. Elective hand hygiene relates to opportunities where instinctive hand hygiene does not occur. Perhaps when hands appear clean, or the area touched is not emotionally dirty (e.g. taking a pulse), yet decontamination is still required. Therefore hand hygiene has to be premeditated, it is not automatic. Whitby et al. (2006, 2007) suggest that it is with Elective hand hygiene that opportunities are more likely to be missed.

1.7. Current Case Study

Central to this research project is the monitoring, measurement and feedback process of hand hygiene compliance. These factors enable accurate assessment, allowing baseline levels to be established, from which the impact of infection prevention interventions can be evaluated. In two parallel studies at an acute Trust setting (Study 1 and 2), an existing audit tool (ICNA, 2004) was used to explore healthcare professional's views on hand hygiene measurement. Perceptions of healthcare professionals regarding the potential of current hand hygiene technologies to help them achieve the hand hygiene audit process more successfully were also investigated. The potential to explore the theory of Inherent and Elective hand hygiene emerged from interviews and discussions. This was investigated in an observational study based on a cardio-thoracic ward at the case study hospital (Study 3).

Domain knowledge, the importance of context and need to include those involved in the studied process, was used to discuss the Fit For Purpose of hand hygiene technology. Human behaviour, here Inherent and Elective hand hygiene, was investigated to determine insights to overcome limitations of current hand hygiene technologies. It was also discussed when considering implementation and communication of the WHO *My 5 Moments for Hand Hygiene*.

1.8. Research Objective

The motivation for the research is two-fold, coming firstly from the need to understand the Fit for Purpose of both audit processes and technologies for measuring hand hygiene compliance to required standards. Secondly, it stems

from the need to recognise the role human behaviour may have in supplementing limitations of existing technologies.

As such, the research question under investigation asked:

> *What is the importance of Domain Knowledge and Human Behaviour for the development of successful Quality Audit Processes and (associated) Technologies?*

The research was conducted over three separate studies (Chapters 4-6). The data from these contributes towards a proposal for a potential future system for hand hygiene measurement, responding to the principle research question (Figure 1-5).

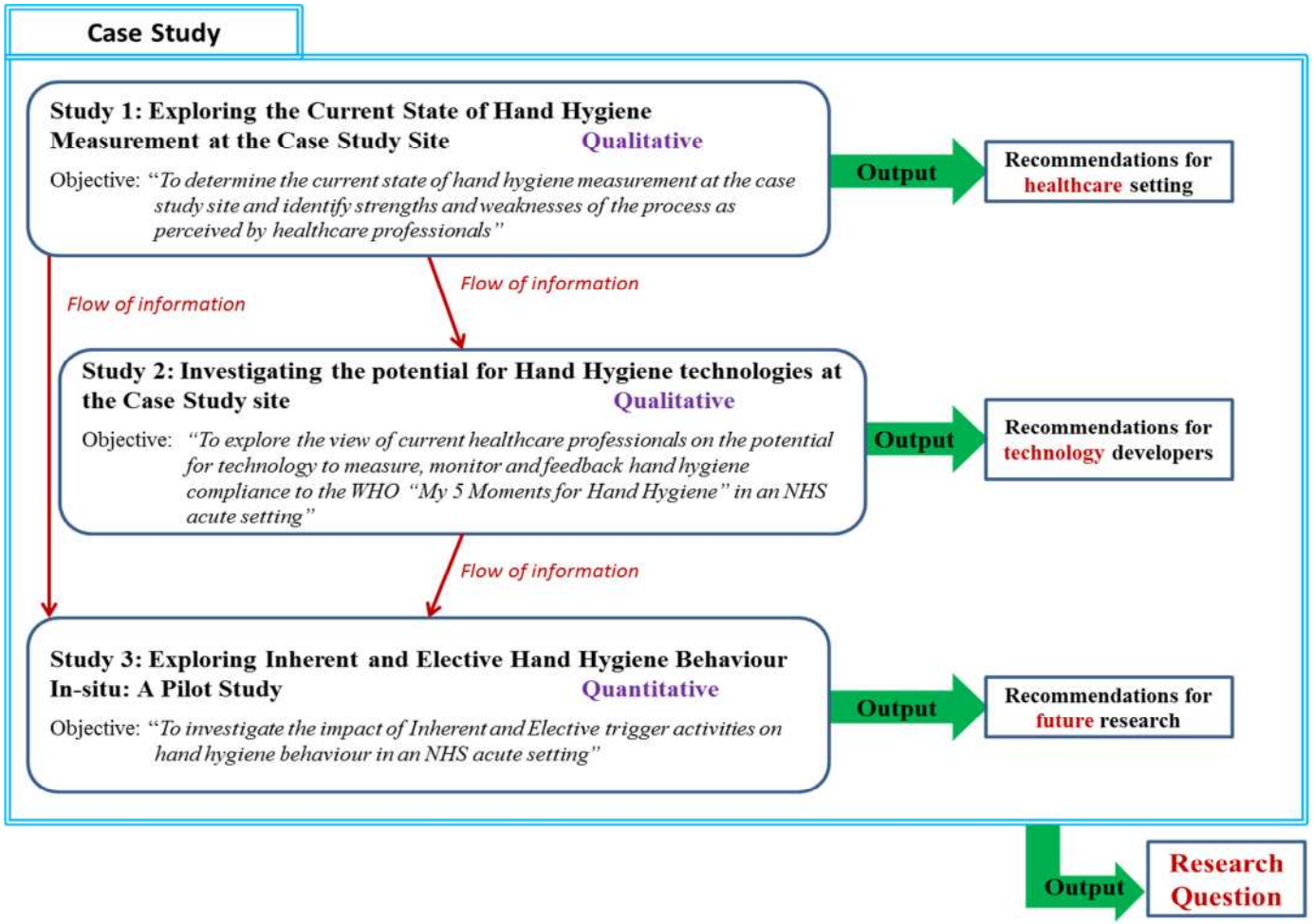


Figure 1-5: Case study structure, consisting of three separate studies each contributing data responding to the principle research question

Each study has a main objective, underpinned by individual aims (Table 1-2).

Table 1-2: Individual Study Objectives and Underpinning Aims

Study 1 **Objective**: To determine the current state of hand hygiene measurement at the case study site and identify strengths and weaknesses of the process as perceived by healthcare professionals.	
Aim 1	Identify tools used
Aim 2	Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
Aim 3	Clarify whether healthcare professionals consider this process to be a burden AND whether they think it has the potential to be improved
Aim 4	Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the burden e.g. would a change of tool help?
Aim 5	Clarify whether healthcare professionals have concerns over data accuracy
Study 2 **Objective**: To explore the view of current healthcare professionals on the potential for technology to measure, monitor and feedback hand hygiene compliance to the WHO *My 5 Moments for Hand Hygiene* in an NHS acute setting	
Aim 1	Determine whether any current technologies available measure/monitor hand hygiene at the WHO 5 Moments
Aim 2	a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with
Aim 3	Using existing case study site hand hygiene audit data identify potential areas where compliance appears particularly a problem. Does this relate to healthcare professional perceptions (Aim 2)? Is there potential for technology to develop a solution?

Aim 4	Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of hand hygiene compliance in their setting?
Aim 5	Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?
Study 3 **Objective**: To investigate the impact of Inherent and Elective trigger activities on hand hygiene behaviour in an NHS acute setting	
Aim 1	Categorise Inherent and Elective trigger activities using literature and data collected from Studies 1 and 2, in collaboration with field experts from the case study site (IPCT)
Aim 2	Using observation in an NHS acute setting, determine whether rates of hand hygiene compliance in healthcare professionals differ for Inherent and Elective trigger activities

1.9. Thesis Overview

To answer the research question, the thesis consists of eight further chapters. These cover the existing literature, research methodology, each individual study in turn, and finally a discussion and conclusion of the work as a whole.

Chapter 2 provides a literature review, outlining the importance of hand hygiene for infection prevention and control, and considering the current state of compliance and measurement. The first part focuses on establishing hand hygiene as a key IPC strategy, examining it within the framework of the Chain of Infection links *mode of transmission* and *reservoir*. Effective hand hygiene is presented as a concept, looking at choice of agent, technique and the evidence base behind current guidelines. Issues surrounding levels of compliance within the healthcare

professional community and the related challenge of ensuring reliable, valid measurement are then addressed. The concept of Quality Management (QM) is then introduced, which allows an exploration of measurement for improvement. This includes the use of auditing, a process widely deployed within healthcare, and for hand hygiene specifically.

Chapter 3 provides a further literature review, introducing two key themes underpinning the current research: hand hygiene technologies and human behaviour. Initially two structured literature reviews are presented. One identifies examples of hand hygiene technologies, the other explores the concept of Fit For Purpose. Secondly background literature featuring the application of behavioural theory to the field of hand hygiene is presented. This leads to the introduction of the major theory used within the current research, Inherent and Elective hand hygiene.

Chapter 4 outlines a case study methodology of hand hygiene measurement within an NHS setting. The multidisciplinary background to the research is presented, culminating in an introduction to the mixed methods approach which provides a framework for the case study. An outline of the case study as a methodology is provided, which further confirms its suitability for the current research. Further detail is provided as to specific research tools, including interviews and observations.

Additional considerations regarding conducting the research, including selection of participants, ethical guidelines and details of the case study site are provided.

Chapters 5-7 each present the individual objective, aims, method, results and discussion of separate studies introduced in Chapter 2. These combine to make up the singular case study (Figure 1-5). These studies draw on influences from the fields of manufacturing, human factors and psychology.

Study 1 explored the current state of hand hygiene measurement at the case study site, a large NHS acute Trust based over two sites. A combination of participatory observation and interviews with those involved in the process was used.

In parallel and following on from this, Study 2 investigated the potential for technology to have a role within hand hygiene measurement at the case study site. The views of the current healthcare professionals involved in the established process were central. This study used the same research tools, with the addition of documents outlining examples of hand hygiene technologies to aid discussion.

Study 3, performed separately from Studies 1 and 2, explored behavioural aspects of hand hygiene. Observations of the hand hygiene compliance of nurses and healthcare assistants at different trigger activities (Inherent or Elective) within a cardio-thoracic unit were taken to investigate whether some activities provoked higher rates of hand hygiene.

Chapter 8 presents a formal discussion of the findings of the current research, bringing together the results and discussed themes from each of the component studies. This allows specific focus to be given to answering the primary research question, and the proposal of a future system of measurement for the field of hand hygiene. Limitations and future research opportunities are also addressed.

Chapter 9 offers the final remarks, thoughts and conclusions from the research.

1.10. Research Contributions

The structure of the current research allowed a number of research contributions to be identified. These stemmed from the individual studies and from their combined response to the principle research question. These contributions are summarised in Table 1-3 and discussed in more depth in Table 1-4.

Table 1-3: Research Contributions and Recommendations

No.	Study	Output Target	Contribution (C) Recommendation (R)
1	1	Recommendations for Healthcare Setting	Methods to establish and reveal domain knowledge **(C)**
2	1	Recommendations for Healthcare Setting	Implementation of full PDSA cycle (Quality Management approach) **(R)**
3	1	Recommendations for Healthcare Setting	Implementation of WHO 5 Moments measurement **(R)** Additional Actionable Feedback model to ensure meaningful data **(C)**
4	2	Recommendations for Technology	Fit for Purpose Matrix for hand hygiene technology assessment **(R)**
5	2	Recommendations for Technology	Inclusion of domain knowledge in hand hygiene technology development **(R)**
6	3	Recommendations for Future Research	Type of clinical activity can affect likelihood of hand hygiene (study design/findings) **(C)**
7	n/a	Future System of Measurement in Hand Hygiene	System of measurement with QM focus: allowing manual and technological data collection, and generation of meaningful data **(C)**
8	n/a	Future System of Measurement in Hand Hygiene	Conceptual splitting of WHO *My 5 Moments for Hand Hygiene* to aid ease of discussion, training, education **(C)**

Table 1-4: Discussion of Research Contributions

No.	Recommendations for Healthcare Setting (Study 1)
1.	Current measurement processes may contain hidden weaknesses. These include data accuracy, efficacy, validity of produced data, and perceptions of meaning amongst those involved with the process. Use of domain knowledge, through identifying and involving individuals from all areas of a given process, can allow access to hidden weaknesses, providing clarity. In the current research two novel diagrams allowed this process to occur: API Diagram and New Current State Map. These may offer benefit as frameworks for adaptation in other settings where process evaluation is desired.
2.	Lack of integration of routine auditing with additional Quality Management (QM) systems was highlighted as a potential explanation regarding unclear feedback loops revealed via participants in Study 1. A recommendation from the research was the implementation of a QM approach of Plan, Do, Study, Act (PDSA) cycles. The aim was to rebalance the focus from chiefly being on systematic data collection (*Do*) to considering the implications of collected data (*Study*), and courses of action appropriate for desired improvement (*Act*, *Plan*).
3.	Lack of meaning was found to be a major perceived weakness of the existing system of measurement at the case study site. This included a disconnect between the content of training and education priorities, felt to be centred around the WHO *My 5 Moments for Hand Hygiene*, and the measurement criteria, which utilised the ICNA (2004) Hand Hygiene Audit Tool. A recommendation of the research was that the case study site moves to a tool based on the WHO 5 Moments, providing a basis for meaningful feedback. Further, an existing model of actionable feedback was adapted to provide guidance when considering new forms of measurement, to ensure generated data is able to provide meaning, aiding performance improvement.

	Recommendations for Technology Developers (Study 2)
4.	Fit For Purpose (FFP) of existing hand hygiene technologies was assessed using a specifically designed matrix, evaluating their ability to monitor, measure and feedback data on hand hygiene at each of the WHO 5 Moments. This tool is seen as a simple, effective scorecard approach to allowing technology developers, and potential customers, to establish whether innovations possess sufficient capabilities for the objective desired. This is particularly important in light of the previously established requirement for measured data to possess meaning for those involved within the process. Therefore the FFP matrix, incorporating globally recognised guidelines, would allow clear goals and functional requirements to be set.
5.	The adaptation of a conceptual model from the human factors field (Human-Tech Ladder, Vicente, 2006) was suggested as a potential vehicle for incorporating domain knowledge into the development of hand hygiene technologies, in addition to the use of the FFP matrix. The application of domain knowledge to the assessment of technology examples allowed a much wider discussion of their potential at the case study site than would be possible by just applying the FFP matrix alone. Healthcare professionals offered contextual information concerning why certain technologies would or would not be appropriate. They also offered insight into how they felt technology may have a place for measuring hand hygiene at some, yet not all, the WHO 5 Moments. Such information allowed further research to be planned (Study 3) and also indicated that a perfect score on the FFP matrix may not be required. This would suggest technology developers could produce an innovation deemed useful in the eyes of healthcare professionals which did not need to perform perfectly on the FFP matrix. Involvement of healthcare professionals in the assessment of hand hygiene technologies has previously been sparse. The literature review found only one technology discussing such an involvement, and no work similar to that carried out here in Study 2.

	Recommendations for Future Research (Study 3)
6.	The likelihood of hand hygiene occurring in response to specific clinical activities, categorised as Inherent or Elective, was examined through a pilot study for Study 3. Results indicated that Inherent clinical activities triggered significantly higher levels of hand hygiene than Elective clinical activities ($\chi 2$ (df 1) 11.077, p=<0.001). The study provides the first data of its kind from within an NHS acute setting. The study design developed allows for replication in similar contexts. This can test and refine the framework method, and obtain further data regarding the influence of human behaviour on likelihood of hand hygiene.
	A Future System of Measurement in Hand Hygiene
7.	The data from the three individual studies conducted, and associated discussions, combine to form a response to the primary research question. Both domain knowledge and human behaviour have an important role in the development of quality audit processes and associated technologies, in this example as applied to healthcare hand hygiene. A potential future system of measurement was developed to demonstrate how both concepts could be of benefit. This system allows both manual and technological measurement to be deployed. Data is generated, analysed and fed back within a Quality Management system for improvement.
8.	Within the proposed future system of measurement, and wider discussion, specific focus is placed on the ability to incorporate the WHO 5 Moments. This is to ensure hand hygiene data discussed possesses meaning. A conceptual splitting of the WHO 5 Moments is offered as a starting point for further work. This is based on findings from the human behaviour research (Study 3), which supported the perceptions of healthcare professionals (Study 2). This is to allow for greatest impact when discussing and training/educating healthcare professionals with regard to required hand hygiene priorities and performance.

Chapter 2

Hand Hygiene: Importance, Effectiveness, Compliance and Measurement: A review of the literature

2. Hand Hygiene in History

Within the field of infection prevention Ignaz Semmelweis (1815–1865) is synonymous with the topic of hand hygiene, leading him to be recognised as a father figure of hand decontamination (Pittet and Boyce, 2001).

Carter presents a compelling argument for the contribution of Semmelweis to the discovery that disease transmission, in his case puerperal fever, could be directly linked to the hands of the healthcare professionals.

Semmelweis's work focused on the identification of a cause for puerperal fever, rather than merely a symptomatic definition, more a feature of the time. Whilst leading British medical knowledge of the period had accepted the view of contagion with relation to puerperal fever[4] it was Semmelweis that identified the causing factor as the absorption of decaying matter. Thus puerperal fever could be passed through poor hand hygiene in healthcare professionals (and be endogenous, thus appearing to have no obvious cause). The popular British view on contagion had been that only Patients with puerperal fever could prove a danger to other similar Patients (e.g. pregnant women). Even those who acknowledged that healthcare professionals may play a role in the transmission did not acknowledge that other activities involving decaying matter (e.g. post-mortems on non-puerperal cases) could be equally dangerous as sources of future puerperal fever.

[4] Here Carter adds a footnote that has particular relevance, thus is reproduced thus: *"A year before the first appearance of Holmes's essay,* [the] *Lancet, (1842, i;879) reported that in a discussion of puerperal fever in a meeting of the London Medical Society* 'the chief apparent circumstance is the diversity of opinion...as to the nature...the symptoms and the treatment of the affection....One fact only respecting the disease was generally admitted, namely is unquestionable contagiousness*'"*. (Carter, p.60, footnote 14)

Whilst Carter accepts other medical experts before and during Semmelweis's time made allusions to the cross-contamination of puerperal fever, he argues it is apparent in the existing documentation from the period that Semmelweis's voice alone directly attributed the spread of the illness solely to decaying matter and the need for hand hygiene, without accepting there may also be other explanations. For example, Carter notes Frederich W. Scanzoni, who, whilst acknowledging Semmelweis's theory regarding the role of hand hygiene in the spread of puerperal fever may partly explain causality, Cater argues...*insisted that the disease was primarily due to atmospheric or miasmatic influences and that it could sometimes be caused by other factors as emotional trauma.* (Carter, p.67)

However, despite such posthumous accolade it is similarly well documented that Semmelweis suffered opposition from much of the medical community during his lifetime. This arguably contributed to his early death (Pittet and Boyce, 2001). In the 150 years following, with the benefits of scientific advancement, evidence continues to mount in support of his original stance as to the importance of hand hygiene. This notion is to be addressed in the forthcoming sections.

2.1. Why is Hand Hygiene Important?

The opening section of this thesis outlined the background to the research with reference to the Chain of Infection (Damani, 2003). The links of causative agents, susceptible hosts and portals of entry/exit were examined. Microbiological agents, Patient susceptibility requiring increased therapeutic interventions, and the danger of poor hand hygiene when caring for Patients were briefly discussed with reference to these links in the Chain of Infection.

This section, focusing on hand hygiene, explores the two remaining links in the chain: mode of transmission and reservoir (Figure 2-1). Firstly the evidence for hands as vectors for pathogens is explored for the mode of transmission link. Secondly evidence relating to environmental contamination is offered as an example of the reservoir link. Together these will be used to support the concept that effective hand hygiene is essential to prevent cross-transmission of infection.

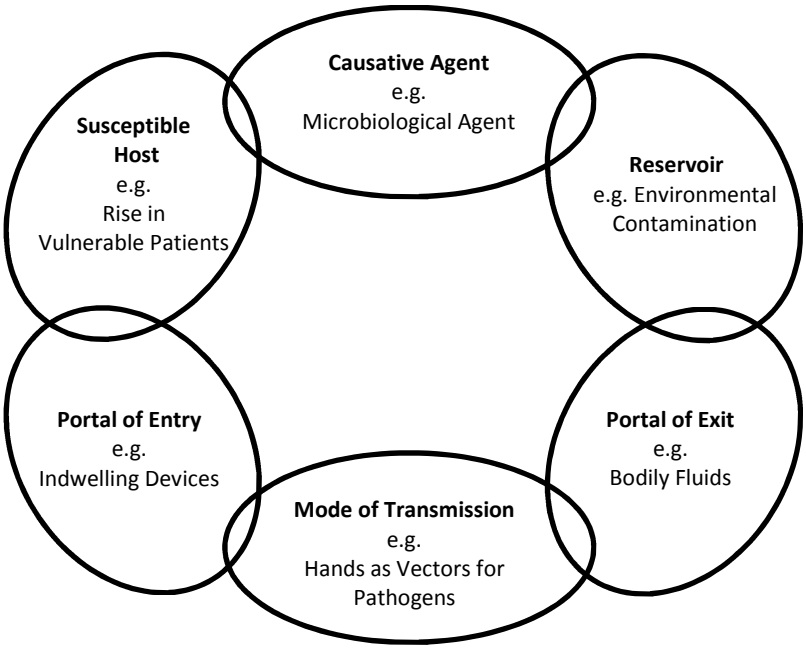


Figure 2-1: Adapted Chain of Infection diagram with examples of potential risk factors for each link

2.2. Mode of Transmission: Hands as vectors for pathogen transmission

Hands have been proven to be vectors for transmission of bacteria and other pathogens within the healthcare setting. In essence such evidence can be traced back to the work of Semmelweis, where the link between hand hygiene and Patient outcome could be seen. However it is to more recent and arguably more empirically solid research that the focus of this thesis now turns, to confirm the potential role of hand surfaces in the transmission of infection.

2.2.1. Hand Transmission

Microbial analysis has shown that the surfaces of the hands are, in their natural state, covered in microorganisms. Pittet et al. (1999b) divides these into two groups:

1. Resident Flora: organisms that reside on the surface of the hands
2. Transient Flora: contaminants that come into contact with hand surfaces

It is transient flora which is of concern in terms of the Chain of Infection, as in the words of Pittet et al. (1999b)**:**

> *Unless introduced into body tissues by trauma or medical devices such as intravenous catheters, the pathogenic potential of resident flora is usually regarded as low. In contrast, transient flora causes most nosocomial infections resulting from cross-transmission.* (pp. 821)

Bauer et al. (1990) proposed four accepted routes for microbial cross-transmission within medical (predominantly ICU) settings: 1. Hand transmission, 2.Food and Equipment (Millership et al., 1989), 3.Aerosols (Dandalides et al., 1984) and 4.Air (Bengtsson et al., 1979).In their account, they documented the acknowledged evidence for the role of the air route in the cross-transmission of some non-viral organisms, including *Staphylococcus* spp. (Bengtsson et al, 1979), *Streptococcus* spp. (Cruickshank, 1935), and fungi. However, they noted a lack of clarity relating to how this information further related to incidence of HCAI, and its comparative impact with the hand transmission route.

To address this lack of clarity they conducted a seven week bacteriological survey on a seven bed medical ICU ward. Three times a week samples were taken from each of the following categories:

1. Handwashing cultures (from personnel from each of three shifts)
2. Air samples
3. Patient samples (tracheal secretions from intubated Patients; urine from catheterized Patients; swabs from infusion sites/wounds showing signs of infection; cultures from ventilator humidifiers)

Handwashing samples (328) from 39 staff members were evaluated and 97 air samples were taken. The average air colony counts showed 447 colony forming units (CFU). From the 53 Patients tested, nine produced bacterial samples. Crucially seven out of the nine Patients had indistinguishable organisms also found on the hands of their nursing contacts. This was compared to only one of the nine Patients displaying a link between Patient and previous air contamination.

Bauer et al. (1990) thus concluded that direct Patient-Staff contact was the most important route of microbial cross-transmission, over and above the air route of transmission. Critical to their stance was the finding that the array of bacteria recovered from the Patient samples was different from that recovered from those grown in the air source.

The study may be limited by sample size (*N*=39), being located in a single setting and stemming from a relatively short study duration of seven weeks. However, the findings indicate a clear difference between sources of contamination. Cross-transmission was much more likely to occur in a medical setting due to Patient-Staff hand contact than through an airborne route.

2.2.2. Hand Contamination: Patient to healthcare professional

An experimental setting was used by Ehrenkranz and Alfonso (1991) to determine the risks of pathogen transfer from colonised Patients to healthcare professional hand surfaces, and subsequent contacted surfaces. Their design involved controlled contact between healthcare professionals and a Patient known to be a gram-negative bacteria carrier. A two-period cross-over design with two 15 second contacts per hand, followed by hand hygiene with either plain soap or alcohol rinse was employed. After performing hand hygiene, and a specified waiting time (one minute), catheter manipulation was executed to a required pre-determined 15 second sequence. From Patient contact to catheter manipulation, during which time the hand hygiene occurred, was approximately four minutes in each case. Two data readings were recorded in this study, with collection of glove juice after the Patient contact stage, and after the catheter manipulation stage.

Whilst the study is admittedly limited in scope, involving only six healthcare professionals in one Nursing Home setting, the findings provide evidence for the role of hands as vectors. This occurred from both Patient to healthcare professional, and then further to the surrounding environment. Ehrenkranz and Alfondo (1991) found that despite the use of the soap wash (post Patient contact), contact with the known gram-negative bacteria Patient routinely led to transfer to the healthcare professional and the catheter later manipulated (for *Proteeae* species in 11 out of 12 experiments). The use of the alcohol was more effective, reducing this transfer to two out of the 12 experiments, supporting the notion of appropriate hand hygiene (i.e. with proven agents for hygiene, see 2.4.).

The study is arguably limited by its experimental design, thus the activities used may not replicate how Patient care processes or hand hygiene levels would operate during normal Patient care routine. Indeed, the authors note that the Patient contact site used, close to the groin to simulate checking the femoral pulse, is one perhaps rarely used within a Nursing Home setting, yet much more likely within an ICU. Thus empirical evidence from studies carried out using in-situ Patient care must also be examined. This can establish a more rounded and ecologically valid picture (i.e. sampling the individual's behaviour in the real world; see Shiffman and Stone, 1998).

Pittet et al. (1999b) carried out in-situ research for three months across a range of eight wards within a large (~2,000 bed) University Hospital in Geneva, Switzerland. A far greater sample of staff than used by Ehrenkranz and Alfonso (1991) were recruited for this study (417 vs. 6 respectively). Each of these participants was observed performing a routine episode of Patient care, ending with hand hygiene, after which a five-fingertip sample was collected to allow for bacterial CFU to be analysed. The findings support the claim that healthcare professional hands became contaminated through routine Patient care. However the authors are self-critical of their study, due to pitfalls associated with the use of overt observation. Using an in-situ design may add more realism to the research than using an experimental model design like Ehrenkranz and Alfonso (1991). Nevertheless the same limitation of whether the equivalent level of hand hygiene observed during the study would indeed occur during routine Patient care processes carried out by healthcare professionals under non-observed conditions remains. This observer-bias or Hawthorne Effect is discussed more later.

A further study that may suffer from the limitation of observer bias is that of Pessoa-Silva et al. (2004), who conducted their study in-situ, using a 20 bed Neonatal Unit of a large tertiary teaching hospital in Geneva, Switzerland. Here healthcare professionals were observed carrying out routine models of Patient care. Unlike the artificial scenario outlined in Ehrenkranz and Alfonso (1991), samples of hand surface pathogens were collected at specific points during these care processes. Samples were taken before applying hand rub, after applying hand rub and directly following the episode of Patient care (prior to any hand hygiene). Observer bias may have occurred due to the artificial nature of the healthcare professional having their care routine interrupted in order to take samples. In summary the authors found that all types of care observed (that did not include healthcare professionals using gloves) were associated with a significant increase in the bacterial contamination of the hands of the healthcare professionals, measured in CFU. The limitation of observer bias, as with the Pittet et al. (1999b) study does not detract from the finding that healthcare professional hands became contaminated through Patient care processes.

2.2.3. Hand Contamination: Specific Pathogens

With relation to specific pathogens, as opposed to the more generalised contamination of hand surfaces already discussed, Creamer et al. (2010) investigated the presence of MRSA on healthcare professional hand surfaces (fingertip analysis), having noted a scarcity of such empirical evidence within the field. Their study, involving over 500 healthcare professionals (*N*=523) based at a 700bed acute tertiary referral hospital assessed hand contamination at seven specific points of Patient care: (1) before/ (2) after social Patient hand contact, (3)

before/ (4) after clinical contact with Patient, (5) before / (6) after exiting an isolation room and (7) after contact with ward equipment/the environment. The research recovered a finding of MRSA contamination of 5% from all 822 samples taken. That is, MRSA was recovered from 38 of the 822 fingertip samples taken from 523 healthcare professional participants over the nine week, two-phase study. A breakdown by Patient care point (i.e. 1 to 7) is provided by the authors (pp. 108). Of particular note here is that After Clinical Contact with Patient (Point 4) resulted in a 6% MRSA contamination finding (12/194), and there was a 10% MRSA contamination finding for After Environmental Contact (10/138) (point 7). Further discussion of environmental contamination is presented shortly.

Thus additional support is given to the concept of hands as vectors for pathogen transmission, here with specific reference to MRSA. The authors accept that their findings of positive MRSA samples may be skewed by inadequate drying. Also limiting the study is the previously discussed issue of observer bias. However as this may have produced a positive Hawthorne effect, increasing hand hygiene and in turn potentially reducing hand contamination, this may in part alleviate some of the limitation of the positive-skewing of the premature sampling of inadequately dried hands, which may have over-estimated levels of hand contamination; however this is speculative. A further limitation, acknowledged by the study authors, is that the research was predominantly carried out during the day-shift (split by morning and afternoon sessions), thus may not be representative of other periods of Patient care when hand hygiene levels may vary e.g. night-shift (Sahay et al., 2010).

The studies of Pessoa-Silva et al. (2004), Pittet et al. (1999) and Creamer et al. (2010) do not, however, imply a causal relationship between hand surface contamination and subsequent infection. This may be seen as a limiting factor to the argument in support of hand hygiene. However, studies investigating the role of hand surface contamination in infection outbreaks can be used to move towards this causal link.

2.2.4. Hand Contamination: Outbreaks

Following an outbreak of a specific HCAI (*Acinetobacterbaumannii*), El Shafie et al. (2003) assessed the spread of the infection from one admitted trauma Patient to a resultant 21 Patients over a six month period (January-June 2001). Whilst no molecular typing was performed across the cases, all strains analysed from Patients and from samples swabbed from the ward environment and healthcare professionals had the identical antibiogram. The authors noted that all the swabs also produced carbapenemase, cephalosporinase and acquired penicillinase, factors they argue indicate a high possibility of a single circulating strain. Further investigation was undertaken into the mechanisms of transmission of this strain. Evidence suggested that spillage of respiratory secretions (during suction procedures, leading to aerolisation) may have contaminated the immediate Patient environment (e.g. Patient bed rails). The authors suggest that healthcare professional hands (found to be contaminated with the same strain) then became the vectors of transmission to subsequent Patients. This hypothesis was further supported by an analysis of the staffing policy. Whilst the ward had a 1:1 Patient: healthcare professional ratio, breaks were covered by staff from within the unit. This allowed the potential for cross-contamination from a contaminated Patient to

a non-contaminated Patient. Once infection prevention and control (IPC) strategies (including closed suction, environmental cleaning and strict before/after Patient care hand hygiene) had been implemented the outbreak was contained and no further cases occurred. This supported the identification of these factors (including hand surfaces as vectors) as mechanisms of transmission.

Further support for the role of hands as vectors from outbreak analysis comes from Zawacki et al. (2004). Here four fatal neonatal cases of *Pseudomonas aeruginosa* blood stream infection (BSI) over a six week period (13th July–30th Aug 1997) were investigated in the setting of an 18 bed NICU (Neonatal ICU) in New England, USA. A further case from February 1997 was identified once the outbreak was being investigated, thus five case-Patients were included.

As part of the investigation hand cultures were taken from 178 healthcare professionals who had working contact with the unit, five of these returning positive for *P. aeruginosa*. The use of genotyping (see paper for details) allowed four of these specimens to be excluded from the investigation, as they did not match with the neonatal cases. Further samples taken over a seven day period from the remaining healthcare professional revealed continuing presence of *P.aeruginosa*, with samples from other body sites returning positive from the external ear location (negative elsewhere). Analysis of care records revealed that four of the five case-Patients had been cared for by this healthcare professional, later identified as having positive hand cultures of the same genotype. This was compared with other neonates of similar background (matched on, for example, weight, gestational age) of which the same healthcare processional cared for 5 out

of 15. The authors present this exposure to the healthcare professional as a likely association with a significance value of p=0.05.

The outbreak was halted with the implementation of a barrage of IPC measures, including the reassignment of the specified healthcare professional to non-clinical duties. The individual was also treated for the *P. aeruginosa* ear colonisation. This was found to lead to subsequent negative tests of both ear and hand culture samples, in combination with a new stringent hand hygiene regime. The authors agree that whilst the evidence for an ear-hand-Patient mode of transmission may be persuasive, it could not be proven definitively. However, it does appear the most likely explanation, especially in light of weaknesses cast on the alternate explanation of contaminated equipment. Equipment was effectively decontaminated prior to the fourth case occurring, and also had low findings with relation to the specific genotyped strain.

2.3. Environment as Reservoir

The final link in the Chain of Infection is that of the environment as a reservoir, whereby contamination in the surrounding area becomes a source of infection through inefficient or non-existent removal of micro-organisms. These pathogens may then find their way to a susceptible host, via other previously discussed modes of transmission.

Boyce (2007) summarises published levels of contamination in hospitals, highlighting the variation, with levels ranging from 1-27% of surfaces in Patient rooms on '*regular hospital wards'*, to a '*few per cent to 64% of surfaces in burns units with MRSA patients'* (pp.51).

It is acknowledged that there is a key difference between colonisation and infection (see Glossary). Further it is understood that the majority of micro-organism transfers from the environment to the Patient result in colonisation (Sax et al., 2007). However preventing cross-colonisation is seen as a target of hand hygiene as the transfer of (multi-resistant) microorganisms can been seen to both contribute to increasing antimicrobial resistance and a reservoir of potential pathogens (Sax et al., 2007). In terms of HCAI, cross-colonisation can lead to exogenous cases, whereby introduced pathogens find an entry to the Patient, particularly in vulnerable situations such as heightened immune-suppression or existing portals of entry (e.g. IV catheters) (Bhalla et al., 2004).

2.3.1. Patient Room Occupation: An example of Environmental Contamination (MRSA)

Boyce (2007) cites Otter et al. (2006) as an example of specific healthcare research into environmental contamination, focusing on high-touch surfaces within Patient rooms. In this comparative study, the authors selected eight Patients with Gastrointestinal (GI) MRSA colonization and concomitant diarrhoea (cases) and six Patients with MRSA at other body sites but clear stool samples (controls).

Samples taken from case rooms revealed that where GI colonisation and concomitant diarrhoea was present 59% of surfaces were contaminated with MRSA.A breakdown of these cultured results found that the bedside rails were contaminated100% of times. In 88% times there were MRSA positive samples on the blood pressure cuffs. Such contamination was found on 75% TV remote controls, and on 63% of bedside tables. This was *higher* than the findings from

toilet seats (63%), toilet rails (50%), toilet dressers (50%), door handles (38%) and IV Pumps (25%).

In comparison, in the control rooms where Patients had clear stool samples, only 23% of surfaces tested were found to be contaminated, significantly lower than in the case rooms. When comparing specific locations, bedside rails were again found to be most likely to be contaminated, found in 67% of samples taken. Toilets and call buttons were the next most likely areas, both returning positive samples 37% of times. All the other seven sites in the control rooms returned positive samples less than 20% of times. The implications for such findings, regarding how they may lead to spikes and troughs of hand hygiene compliance, are discussed in Chapter 7, a study which investigates hand hygiene behaviour.

Whilst the Otter et al. (2006) study involved a small sample (N=14) at a single site, the findings are illustrative of the issue of environmental surfaces as potential reservoirs for contamination, here for the HCAI MRSA. Though this individual research does not demonstrate the cross-infection process, in that it does not show infection occurring in a Patient or healthcare professional, it implies such a risk. This is due to enabling the continuation of the Chain of Infection. In the case of MRSA this risk is of particular concern considering evidence that routine hospital cleaning measures are not always effective in removing MRSA contamination (Bhalla et al., 2004; French et al., 2004).

2.3.2. Environmental Contamination: Patient Infection

The limitation of the Otter et al. (2006) reported findings, of a lack of evidence to support the link between environmental contamination and subsequent Patient

infection, can be addressed using an outbreak study presented by Schultsz et al. (2003). This investigated an MRSA outbreak within the nine bed head and neck surgical ward (HNS) of a 703bed tertiary care University hospital in Amsterdam, Netherlands.

The initial source case was identified via a positive sputum culture taken in May 2000, from a Patient admitted in April. Screening of Patients recently discharged and currently present in the unit revealed a further four colonised cases. This led to the introduction of isolation procedures for the care of in-Patients identified as colonised. Despite staff screening and other attempts to trace the MRSA source (i.e. previous Patient locations), no outbreak source was identified. Thorough unit disinfection was conducted, and no new cases identified, resulting in the outbreak being declared over in July 2000. However, a further case of MRSA colonisation was found through screening in mid-August 2000. The Patient had been transferred from the unit to an additional unit (surgical intensive care unit [SICU]) and back. Screening of Patients in the HNS found four further colonised cases (one now moved to medical ICU), and screening of the SICU found colonisation of three further Patients. Once more IPC measures were implemented and disinfection of all three units (HNS, MICU, SICU) was conducted, however at the beginning of September 2000 two further colonised Patients were found on the HNS.

Extensive IPC measures were implemented which, the authors argue, eliminated the potential source of colonisation being existing Patients, incoming Patients or healthcare professionals working within the affected wards. When a further Patient was found to be colonised four weeks post-IPC implementation, the

environment as a reservoir hypothesis was firmly suspected. This was supported by the existence of three previously negative samples from the same Patient. Subsequent samples taken from the identified Patient's room recovered positive MRSA samples from two ultrasonic nebulizers.

Detailed analysis found a flaw in the cleaning process had led to nebulizer dust filters not being cleaned weekly, despite protocol recommendations. These dust filters were the site of MRSA positive samples. Following correct nebulizer decontamination, and a return to correct cleaning protocol, no further new Patient colonization occurred. The outbreak was declared over in March 2001, at which point the use of ultrasonic nebulizers on the HNS was no longer standard procedure.

As with previous examples (El Shafie et al., 2003; Zawacki et al., 2004) outbreak study designs have limitations owing to a lack of control due to their retrospective nature. Indeed the authors here acknowledge they were unable to trace the paths of the nebulizers to conclusively prove the transmission of MRSA to each of the colonised Patients. This would have been the ideal scenario, but was not policy on the HNS, where nebulizers were shared as a unit facility. However, due to the lack of new colonisation after the identification of the nebulizers as the reservoirs of MRSA contamination, and effective decontamination, the hypothesis for their role in the infection pathway is arguably upheld. Further support was added by negative swabs taken from healthcare professionals and Patients prior to the final colonised case being discovered (circa October 2000, four weeks after final extensive IPC methods introduced).

This study illustrates that despite extensive IPC measures, including regular screening and barrier nursing as implemented here, HCAI may still occur if any one of the links in the Chain of Infection is overlooked. Here a flaw in cleaning protocol allowed the environment to become the reservoir for dangerous pathogens.

The detailed study of Schultsz et al. (2003) carries a similar message to that of Kumari et al. (1998) from some five years previous, describing another MRSA outbreak, this time in a hospital in the North-East of England. Another outbreak study, here the source was identified as ventilation grills linked to the hospital heating and cooling system. Occurring due to a chimney effect caused by a power-saving exercise leading to intermittent switching on/off, airborne particles were being sucked/blown across the environment. As the grills were never cleaned the dust within the system became polluted with MRSA contaminated flora from a transferred Patient. The system became a reservoir for the pathogen in spite of cleaning elsewhere and strict IPC measures.

These two outbreak studies are only a sample of a number which illustrate potential sources of environmental contamination which may provide the essential link for the continuation of the Chain of Infection. Other sources of references include Cotterill et al. (1996), similar to that of Kumari et al. (1998) and Schultz et al. (2003) with a focus on hospital fixtures and fittings [Exhaust ducting], and work on equipment contamination, including Livornese et al. (1992) [Electronic rectal thermometers], Porwancher et al. (1997) [Electronic ear thermometers] and Falk et al. (2000) [Contaminated EKG leads].

Each of these studies demonstrates the importance of thorough outbreak investigation, as well as the reactive requirement of IPC, with an emphasis on exploring the potential of the environment as a source of any HCAI. This is particularly important with the issue of hand hygiene, as whilst effective hand hygiene would reduce the risk of transmission, compliance rates to guidelines are often found to be significantly less than 100% (Bolon 2011).Therefore the more heavily contaminated the environment, the higher the risks are of transference from a reservoir of infection, via the hands of the healthcare professional, to a susceptible host i.e. the vulnerable Patient.

2.4. From Environment to Hands

Bhalla et al. (2004) allows the connection between the links of the environment as a reservoir and mode of transmission, to be seen in an HCAI example.

They investigated the hypothesis that nosocomial pathogens would be acquired frequently on the hands of healthcare professionals having contact with surfaces near Patients in their institution who had not been placed in contact precautions (e.g. isolation, barrier nursing). Bhalla et al. (2004) used a culture survey methodology on eight wards of a 368bed acute care medical facility over a two week period. Healthcare professionals disinfected their hands prior to contact with a Patient's bed rail and bedside table (using an alcohol rub, and a blood-agar plate to ensure no pathogens were present on the hand surface). Each surface was touched for five seconds. If neither surface was available an alternative within Patient reach surface was used. The hand was then imprinted onto an agar plate and microbiological analysis took place over 48 hours.

The authors found positive hand imprint cultures after contact with surfaces in 34 (53%) of 64 occupied Patient rooms for one or more of the four nosocomial pathogens assessed for (VRE [Vancomycin-resistant *Enterococcus*], gram negative bacilli, *S. aureus*, and CDI). This was also true for 24% (6 out of 25) of the rooms that had been cleaned post-Patient discharge. Whilst the study fails to provide the final link in terms of displaying Patient to Patient cross-contamination, it does highlight that pathogens may remain in the environment, even after cleaning, ready and able to be transferred to hand surfaces. If hand hygiene is not effectively carried out, this could then be transferred to a suitable host.

The authors acknowledge the limitations of their study, including the small and arguably unrepresentative sample (i.e. predominantly elderly male Patients) and the use of brief hand contact with surfaces which may not be representative of daily care duties. However, as seen with Otter et al. (2006), bed rails and Patient tables are surfaces highly likely to be contaminated. Indeed, in the earlier study of Weber and Rutala (1997), a review of VRE colonization studies, they found that the most commonly contaminated sites in hospitals were bedside rails, tables, blood pressure cuffs and floors. Less commonly contaminated surfaces included urine catheters and IV pumps. Thus the use of both bedside rails and Patient tables in the Bhalla et al. (2004) study may not give a misleading interpretation as to how healthcare professional hands may become contaminated. Given that such surfaces are located within such close proximity to the Patient, and within the Patient Zone, they are perhaps liable to require frequent contact/moving during daily care routines. However, it is accepted that this is speculative, and a better design would incorporate hand culture swabs from actual care routines. The

relevance of the difference between these two apparent groups of hospital surfaces (featuring high and low contamination) is discussed further in the Chapter 7 with reference to potential links to their role in generating different levels of hand hygiene compliance, with possibly damaging consequences. In brief, the concept discussed, Inherent and Elective hand hygiene, suggests that it would be those surfaces with the highest levels of contamination (e.g. bedside rails) which would actually be least likely to trigger hand hygiene compliance. However those featuring the lowest levels of contamination (e.g. urine catheters) would be most likely to trigger healthcare professional hand hygiene (Whitby et al., 2006).

With regard to length of contact, increased contact through daily duties has been seen to increase hand contamination (Pittet et al., 1999b). Therefore this study by Bhalla may be faulty of under-estimating contamination, rather than over-estimating. It would be expected that if longer contact times had been used in the study they would have produced higher levels of contamination, further supporting their findings. Therefore their limitation of short-contact times can perhaps be argued to not greatly affect the underlying argument, that environmental contamination can be transferred to the surfaces of healthcare professional hands.

Bhalla et al. (2004) are not alone in showing that hand surfaces of healthcare professionals can become contaminated without direct contact with Patients. Similar supportive evidence can be found from the work of Tenorio et al. (2001), exploring VRE within a healthcare setting, using 50 healthcare professionals carrying out normal Patient care activities. The study was designed to test the efficacy of glove use to protect from VRE cross-contamination, thus microbial

analysis was taken pre-and post-glove removal. Participants already found to have VRE contamination prior to the analysis were excluded (six in total), leaving 44 for the glove-testing phase. Of these 17 were found to acquire the same VRE strain from the Patient when their gloves were tested. Furthermore, five of these 17were found to have the VRE on their hands once their gloves had been removed. This indicated that glove usage may not be totally effective in preventing VRE contamination during routine Patient care. What is critical to the argument here is that there were three participants who carried out Patient care which did not include any direct Patient contact (i.e. manipulating items within the room) who were subsequently found to have acquired Patient's strains of VRE on their gloves. Whilst they did not then show acquisition on the hand surface, the glove surface finding does show support for the risk of transference between environmental contamination and hand contamination through normal care activities. This suggests that contamination of the hand surface would have occurred if the gloves had not been present.

This finding is in line with the earlier study of Boyce (1997), using the context of working in a room occupied by a Patient with MRSA in either a wound or urine sample. Almost half of sampled nurses (five out of 12) tested positive for MRSA in a glove surface test after performing routine Patient care involving contact with inanimate objects.

2.4.1. The role of Hand Hygiene and the Chain of Infection

The previous sections, both in the introduction and through the sections on mode of transmission and environment as reservoir, demonstrate the role of hand surfaces in the process of cross-infection. This highlights the importance of

effective hand hygiene to break the Chain of Infection. In the next section, on hand hygiene compliance, the apparently counter-intuitive situation of poor levels of compliance within healthcare will be presented. This includes a brief summary of potential factors affecting adherence levels, and wider discussion on the complex challenge of how to accurately measure hand hygiene.

2.5. Effective Hand Hygiene

Once the need for hand hygiene has been established, through an understanding of modes of transmission and identifying the environment as a reservoir, the requirement to ensure that practiced hand hygiene is effective is paramount. The 2009 WHO guidance document provides a definitive review of suitable hand hygiene preparations (section 11, pp. 30), including considerations regarding context specific concerns (e.g. water quality). The objective here is not to reproduce such literature, but to briefly summarise key aspects relating to effective hand hygiene. These have particular relevance to the concept of measurable behaviour, a main theme of this research.

Of use in considering effective hand hygiene is the figure provided by Sax et al. (2007) (Figure 2-2), where the authors define the concept:

> *Effective hand cleansing can prevent transmission of micro-organisms from surface A to surface B if applied at any moment during hand transition between the two surfaces*. (pp. 11)

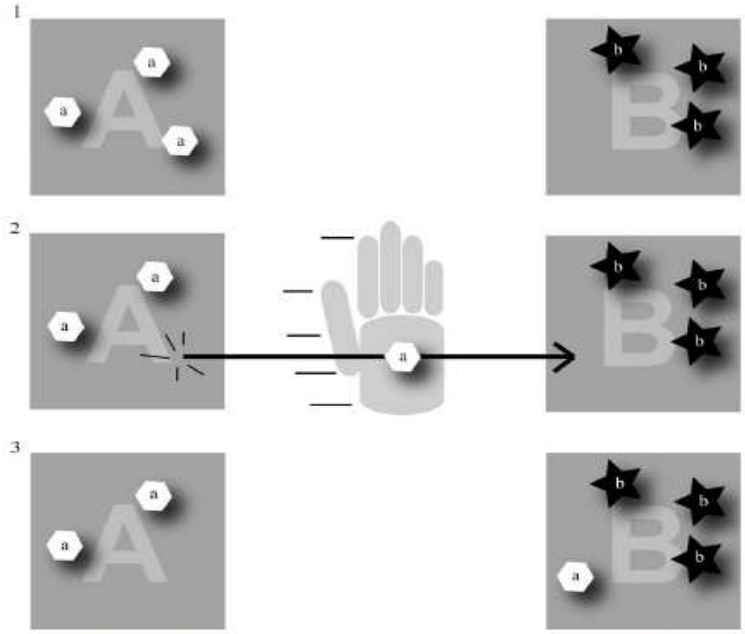


Figure 1 Core element of hand transmission. (1) Donor surface 'A' contains micro-organisms 'a'; receptor surface 'B' micro-organisms 'b'. (2) A hand picks up a micro-organism 'a' from donor surface 'A' and carries it over to receptor surface 'B', no hand hygiene action performed. (3) Receptor surface 'B' is now cross-contaminated with micro-organism 'a' in addition to original flora 'b'. The arrow marks the opportunity for hand hygiene, e.g. the time period and geographical dislocation within which hand hygiene will prevent cross-transmission; the indications for hand hygiene are determined by the need to protect surface 'B' against colonisation with 'a' – the preventable negative outcome in this example.

Figure 2-2: Visual representation of cross-transmission via hand surfaces *(Reproduced from Sax et al., 2007)*

2.5.1. Soap and Water

Plain soap, defined as any detergent based product not consisting of antimicrobial properties (WHO, 2009), possess limited hand hygiene benefits. The main effect of use is to remove visible contamination rather than acting on a microbial level. The WHO (2009) cite data from Rotter (in Mayhall, 1999) showing the reduction of bacterial count on skin through the use of plain soap:

> *…handwashing with plain soap and water for 15 seconds reduces bacterial counts on the skin by 0.6–1.1 log_{10}, whereas washing for 30 seconds reduces counts by 1.8–2.8 log_{10}.*(pp. 30)

They further cite three empirical studies[5]which demonstrate the failure of plain soap to remove pathogens from the hand surfaces of healthcare professionals. In the most recent of these (Bottone et al., 2004), investigators found nosocomial bacterial pathogens (including MRSA, and VREF; Vancomycin Resistant *Enterococcus Faecium*) remained evident on fingertip imprint analyses following five 30 second hand hygiene cycles using a non-antiseptic soap (as used throughout hospital hosting the research). Coupled with the finding that contamination from the fingertips of an individual could be passed directly those of another via direct contact, and endure subsequent hand wash cycles, led them to support the call for hand hygiene to be considered inefficient if soap was used without an antiseptic or alcohol base. This was in line with recent guidelines (Boyce et al., 2002).

A further step supporting a move away from the notion of standard soap and water use as being efficient comes from two citations within the Boyce et al. (2002) guidelines. Here hand hygiene performed with plain soap and water is compared with *some form of hand antisepsis* (pp. S7), the latter found to be favourable in reducing HCAI. As cited by Boyce et al. (2002), Massanari and Hierholzer (1984) found mixed results for decreased HCAI rates associated with hand antisepsis use on different ICUs. Maki (1989), however, demonstrated lower HCAI rates when antiseptic hand hygiene was undertaken by healthcare professionals.

In a final nod towards the use of alternatives to plain soap the issue of contamination of the soap can be briefly addressed. Sartor et al. (2000) compared hospital units known to have had the HCAI *Serratia marcescens* present in the

[5]Ehrenkranz and Alfonso (1991); McFarland LV et al.(1989); (Bottone et al, 2004); See WHO (2009) references for full details, studies 88, 110 and 260 respectively.

last two months (case units), with units without such an incident (control units). (Liquid) soap, soap pump bottles and healthcare professional hand surfaces (pre and post wash) were cultured using a matched-units design. The findings showed a higher rate of *S marcescens* contamination for soap (8/10 contaminations) and soap pump bottles (8/9 contaminations) in the case units than within the control units. Transfer to hands, crucial to the greater picture here, was found to be evident via culture sampling of 63 healthcare professionals. 15 (24%) showed *S. marcescens* contamination after performing hand hygiene. The risk of contamination was found to be 3.5 times more likely if the soap was contaminated and 54 times more likely if the soap pump bottle was contaminated. Finally, analysis from the research period (two months) highlighted a significant association between soap pump bottle contamination and the occurrence of one (or more) incidents of *S marcescens* HCAI. This infers a potential full circle view of how recontamination and reinfection could occur. In recommendations for future practice the authors highlight the dual issues of pump bottle contamination (requiring disposable bottles for future use) and soaps able to resist specific pathogens (in this case *S marcescen*). Strong support is offered for an increase in the use of alcohol based hand disinfectants, especially in light of their documented efficacy and efficiency, as discussed next.

2.5.2. Alcohol Based Hand Rubs (ABHR)

Alcohol preparations, outlined by the WHO (2009) as containing either ethanol, isopropanol or n-propanol, or a combination, have become an increasingly common site in many western healthcare settings. They offer an efficient alternative to hand hygiene with antibacterial soap and water (Voss and Widmer,

1997). ABHR have been tested for efficacy against a myriad of pathogens (e.g. see Boyce et al., 2002, pp. S10; WHO, 2009, pp. 32 for detailed overviews), with the overall summary that it is effective as a counter-measure to gram-positive and gram-negative vegetative bacteria (e.g. MRSA and VRE), however is not effective as a counter to bacterial spores (e.g. CDI). Work by Pittet et al. (1999b) further confirmed the effectiveness of ABHR in comparison to unmedicated soap and water as a method for reducing bacterial contamination on hand surfaces.

In a much cited paper, Voss and Widmer (1997) concisely offer a rationale for the use of ABHR as a time-saving alternative to hand hygiene using a soap and water, with a standardised setting of an ICU for context. Their calculation delivers a proposed time saving of 13.3 hours per shift within the ICU setting studied (based on 12 healthcare professionals working), by switching to ABHR rather than using a soap and water approach. This striking result, from the extreme of their comparison calculations (using an assumed 100% compliance rate), led the authors to suggest that, amongst other benefits, hand hygiene compliance may be positively affected by the time saving promise of ABHR.

Since the publication of Voss and Widmer (1997) ABHR has become commonplace throughout the NHS. It was a cornerstone of the Cleanyourhands Campaign (CYHC), whereby the availability of ABHR at points of care (i.e. Patient bedsides) and ward entrances was a core intervention (National Patient Safety Agency, 2004). The recent evaluation of the CYHC (Stone et al., 2012) revealed dramatic rises in procurement of ABHR (3.4 to 26.0 mL per Patient bed day), attributed by the authors, in the main, to the campaign aims. Encouragingly, results presented by the authors indicated a trend in the last four quarters of the

campaign (Jul 07 - Jun 08 inclusive) interpreted as *an estimated reduction in MRSA bacteraemia of 1%...for each additional mL used per bed day* (pp. 3, and Table 3, pp. 9). Furthermore Stone et al. (2012) cite the publication of the Health Act (2006) as being associated with a significant rise of ABHR procurement. This act included specific guidance on the use of ABHR, including the stipulation that *An NHS body must, with a view to minimising the risk of HCAI, ensure that…. (e) there is adequate provision of suitable hand wash facilities and antibacterial hand rubs* (pp. 5). By comparing the study period prior to the act publication date against the remaining period following publication the CYHC data found ABHR procurement rose post-publication: from 0.68mL per bed day to 0.99mL per bed day.

Concern has been raised about an increasing recourse to ABHR leading to a reduction in soap and water decontamination. Such behaviour could be potentially catastrophic in cases where HCAI pathogens are unaffected by ABHR, as in the case of CDI (Gould et al., 2007). However, in response to the concern of Gould et al. (2007), which directly addressed the CYHC, Stone et al. (2007) cited the Geneva Study (Pittet et al., 2000). This study found that despite the introduction of ABHR, recourse to soap and water hand decontamination remained stable. A similar finding was subsequently found at the evaluation stage of the CYCH (Stone et al., 2012).The acknowledged increase in ABHR procurement was not found to be at the expense of soap procurement, which itself increased dramatically: from 17.4 to 33.8 mL per bed day.

Such a trend was also noted by Whitby and McLaws (2007) who proposed a behavioural explanation for continued soap and water decontamination in the face

of potentially time-saving ABHR use. To be discussed later, their view is based upon the proposition that hand hygiene can be separated into two components: Inherent and Elective. Inherent relates to a sense of "automatic" hand hygiene, linked to perceptions of self-risk, performed when hands are visibly dirty, feel sticky, or in response to contact with an emotionally dirty trigger (e.g. armpit). Elective relates to remaining instances of hand decontamination, whereby an element of learning of appropriate hand hygiene behaviour is required. Whitby and McLaws (2007) suggest ABHR may be more strongly linked to Elective hand hygiene. This is due to the automatic, long-standing association between soap and water decontamination and reduction of perceived self-risk (i.e. Inherent hand hygiene). They suggest an increased use of ABHR is seen due to increased hand hygiene following Elective hand hygiene triggers, perhaps partly due to new interventions (i.e. CYHC posters, availability of ABHR). However, hand hygiene following Inherent hand hygiene triggers is unaffected by new interventions, due to its well-established, self-protection base. Recourse to soap and water is more automatic, therefore levels of soap procurement (as an indicator of soap and water use) remain unaffected by alternate methods of hand hygiene being introduced. Whilst final evaluations of the CYHC (Stone et al., 2012) do show soap procurement increase, contrary to the original suggestions of Whitby and McLaws (2007), this may be explained by the accompanying spike in CDI cases in the UK during the CYHC (see 1.2.). This may have led to institutional-wide emphasis on hand hygiene with soap and water, in addition to heightened perceptions of self-risk, further increasing recourse to soap and water.

2.5.3. Ayliffe Technique

Whether hand hygiene behaviour occurs utilising antimicrobial soap and water or ABHR (depending on context), to be truly effective the technique used must be sufficient to remove unwanted pathogens from hand surfaces.

The Ayliffe technique, recommended by (amongst others) the Royal College of Nursing (RCN, 2012, pp. 10, Figure 1) and the Health Protection Agency (HPA, 2012) outlines required steps to ensure effective hand surface coverage.

Initially featuring six-steps (Figure 2-3), hand hygiene technique posters and promotions have recently moved towards a seven-step technique. This now incorporates decontamination of the wrist area, with the WHO (2009c) publishing guidance involving an eight-step guide for ABHR and an 11-step guide for hand hygiene with soap and water (Figure 2-4).

Figure 2-3: HPA promotional teaching material outlining Ayliffe technique for Hand Hygiene (here, following six steps)
(*Added/Updated to HPA website 11 September 2012)*

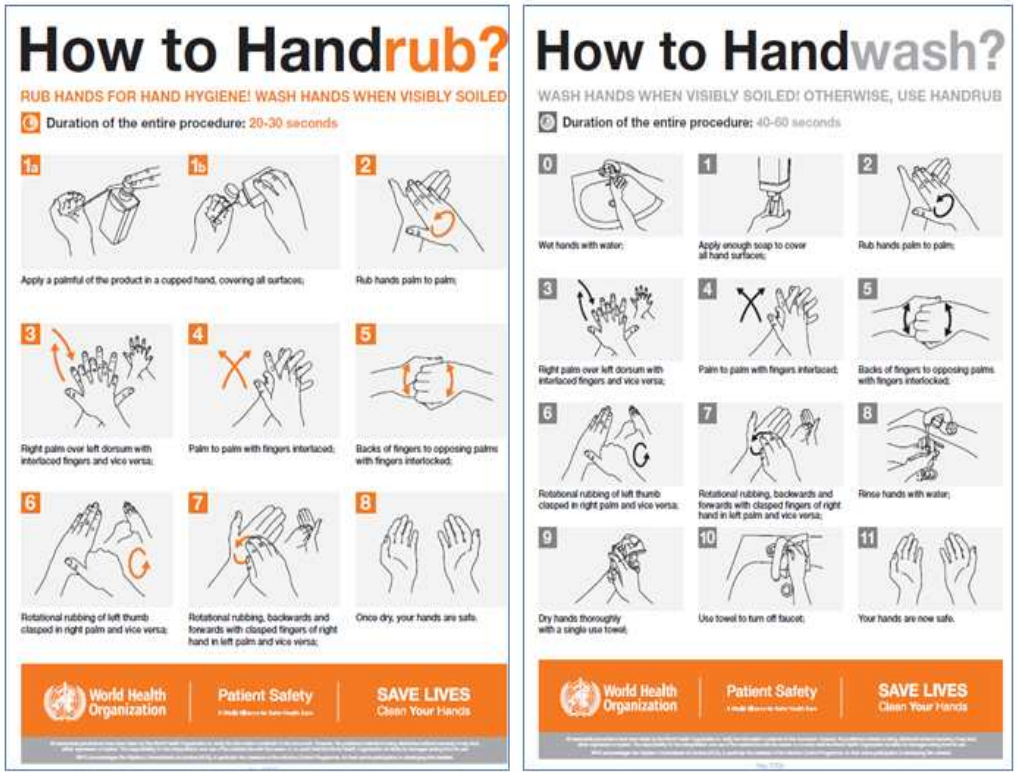


Figure 2-4: WHO (2009c) promotional teaching material regarding How and When to perform hand hygiene, using both ABHR and soap and water decontamination agent

Gould and Drey (2008), in their review of the topic of hand hygiene technique, agree that ensuring full hand surface coverage is a key component of many global guidelines (citing Larson 1995, ICNA 2001, Pratt et al., 2007). However they highlight that continued emphasis of most hand hygiene research appears to be increasing (and measuring) hand hygiene frequency, rather than evaluating techniques being employed. Citing Gould et al. (2007b), Gould and Drey (2008) note that of 48 interventions included, only eight evaluated hand hygiene technique, and these were of mixed methodological design and quality.

The need for a focus on technique was highlighted by MacDonald et al. (2006). They utilised UV technology to assess the hand hygiene technique of 53 healthcare professionals in one orthopaedic department. Efficacy of hand hygiene

technique was assessed using 1.75 ml of alcohol gel containing a clear fluorescent substance, with participants asked to perform hand hygiene as normal. UV detectors were then used to identify areas of hand surface not covered by the gel. Coverage missed ranged from 0% to 34.7%. Feedback was given to the participants visually using the UV detector to show areas missed by current technique. Attention was drawn to a six stage technique (unnamed) via a poster. Following a seven day interlude participants performed the procedure again. Results showed a reduction in overall mean surface area missed from 7.8% to 2.3%. This suggested that awareness of personal limitations with technique combined with reminders regarding recommended technique may improve efficacy of performed hand hygiene. Whilst a small study, the results offered clear recommendations, and the potential for in-house evaluations of technique to be conducted by IPCT. Such training mechanisms have now become widely used within the NHS (Heart of England 2007-8 report, item 6, pp. 14; Plymouth Hospitals NHS Trust IPCT Annual Report Apr 2011 – Mar 2012, pp. 25), with the use of the GloBox at the case study site being discussed later.

2.5.4. My 5 Moments for Hand Hygiene

In addition to the correct decontamination agent and effective technique, the final piece of the effective hand hygiene jigsaw relates to *when* hand hygiene should be performed in order to maximise the likelihood of preventing cross-contamination.

In 2009 the WHO published the *My 5 Moments for Hand Hygiene*[6] to provide guidance on key times for hand hygiene during Patient care to prevent the risk of cross-contamination. Hand hygiene was recommended at five points (Figure 2-5).

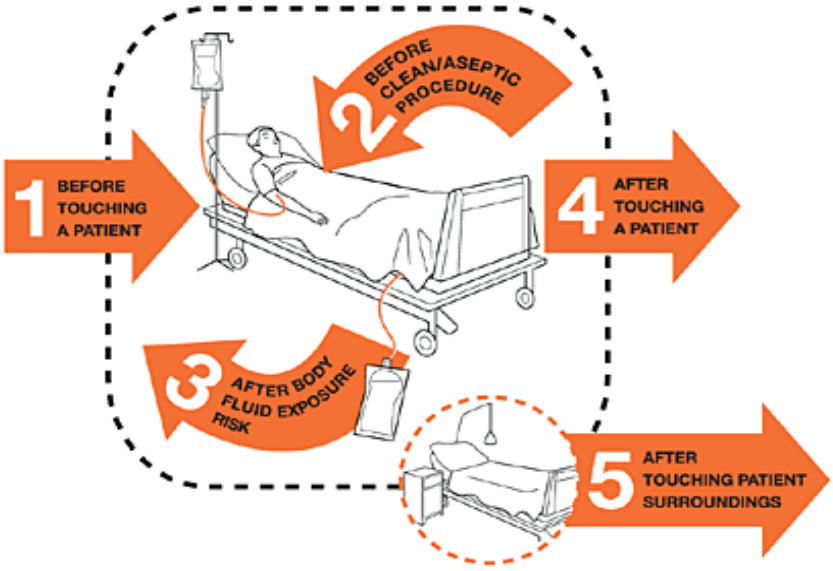


Figure 2-5: WHO (2009) *My 5 Moments for Hand Hygiene* visual representation of opportunities to use hand hygiene to prevent cross-transmission during Patient care

Sax et al. (2007) outline the evolution of these Moments, explaining the user-centred philosophy underpinning their conception and development (see paper, Table 1, pp. 10.). Crucial aspects included the need for ease of learning, integration into workflow and applicability to multiple healthcare settings. Furthermore, a strong focus was placed on the robustness of the approach, relating to its clarity for both trainers and observers, and also those healthcare professionals who are to be observed. Such robustness and clarity in concept, the

[6] Wording of Moments underwent slight change since the original Sax et al. (2007) paper (e.g. Moment 1 "Before Patient Contact" became " Before Touching a Patient", however no change in rationale behind such changes have been discussed, and both versions of the diagram are available on the WHO website; version as used here available: http://www.who.int/gpsc/5may/background/5moments/en/

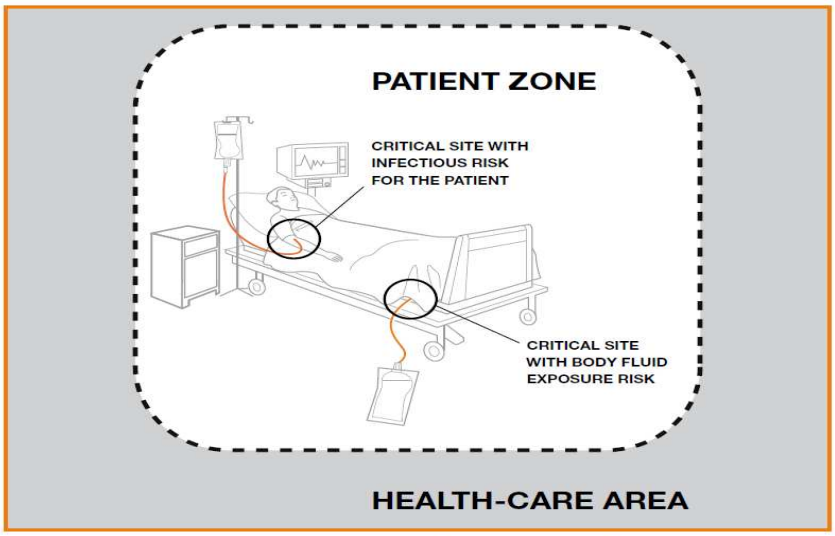
authors argue, can reduce potential limitations such as inter-observer variability. They allow comparison metrics between departments and facilities, and empirical work using the same standards (Rossini et al., 2013; Grayson et al., 2011).

The concept of the 5 Moments addresses endogenous and exogenous HCAI. A Patient may become colonised or infected by microorganisms originating from their own body (endogenous) or from the wider environment (exogenous). It also addresses the role of the healthcare professionals, considering both their potential for harm via the exposure to bodily fluids, and their role in potential cross-colonisation within the healthcare environment.

Sax et al. (2007) summarised these themes as prevention targets of hand hygiene, creating four target points:

> *(i) cross-colonisation of patients*
> *(ii) endogenous and exogenous infection in patients*
> *(iii) infection in HCWs*
> *(iv) cross-colonisation of the healthcare environment including HCWs (*pp.11)

Fundamental to the 5 Moments approach is the concept of a Health-Care Area and a Patient Zone, identified by Sax et al. (2007) and reproduced in discussion by WHO (2009) (Figure 2-6).



The *patient zone* is defined as the patient's intact skin and his/her immediate surroundings colonized by the patient flora and the *health-care area* as containing all other surfaces.
Symbols for *critical sites with infectious risk for the patient* and *critical sites with body fluid exposure risk*, two critical sites for hand hygiene within the patient zone (Figure I.21.5a).
Reprinted from Sax, 2007[5] with permission from Elsevier.

Figure 2-6: Differentiation between Patient Zone and Health-Care Area as used throughout the *My 5 Moments for Hand Hygiene* concept *(Reproduced from WHO, 2009)*

A feature of the user-centred philosophy, the two-zone conceptualisation (Figure 2-6) allowed the model of effective hand hygiene (Figure 2-4) to be translated into a format which could be easily recognised and understood by all exposed to a healthcare setting. The 5 Moments model is then applied using this conceptualisation (Figure 2-7).

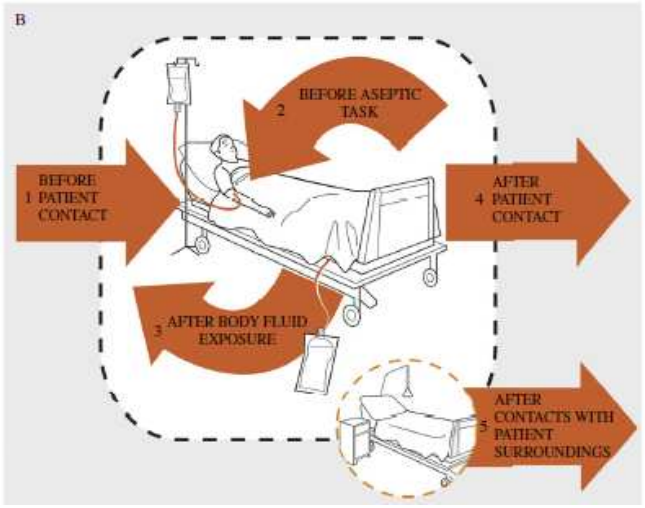


Figure 2-7: The 5 Moments model applied into the Patient Zone concept. *(Reproduced from Sax et al., 2007)*

The authors explain the continued focus on natural workflow as a key influence in the formation of the 5 Moments. The numbering (1-5) of Moments relates to habitual care workflow, thus allowing easier translation into practice by end users. An evidence-based rationale for each of the Moments provides both details of the negative output being targeted for prevention, examples of behaviours covered by the specific Moment, and specified links to the *WHO Guidelines on Hand Hygiene in Health Care*[7] document. When fully launched (2009) these evidence points were translated into brief, easily communicated points, included on promotional and educational material (for example Figure 2-8).

Figure 2-8: WHO educational material for *My 5 Moments for Hand Hygiene*

7At the time of publication (2007) this was an advanced draft of the later full edition referenced throughout this thesis as WHO (2009). Original reference of draft: WHO. Guidelines on hand hygiene in Health Care (advanced draft). Geneva: World Health Organization; 2005.

Chou et al. (2012) question the strength of the evidence base underpinning the 5 Moments approach (Sax et al., 2007), outlining concerns with studies cited as support for the inclusion of each Moment. Their largest concern appears to stem from the lack of conclusive evidence that a failure to perform hand hygiene at one/all of the 5 Moments would directly lead to a HCAI:

> *…the WHO has referenced mostly experimental and observational studies to support their guidelines. Therefore, the science used to suggest that adopting the five moments approach will lead to a reduction in health care associated infections is weak.* (pp. 443)

The challenge of a lack of direct evidence linking the practice of hand hygiene to HCAI rates is complex, acknowledging, for example, the often multi-faceted IPC activities in place to prevent Patient infection. Thus the isolation of hand hygiene as a specific variable may be impossible. The removal of other IPC variables (e.g. barrier nursing, responsible antimicrobial prescribing) to allow a more focused evaluation of the role of hand hygiene is arguably unethical, as would be a more traditional high-quality study approach involving a Randomised Control Trial (RCT) during which time a cohort of Patients would be exposed to a no hand hygiene phase. Indeed, in their response to Chou et al. (2012) the original authors of the 5 Moments (Sax et al., 2007) highlighted the ethical and practical difficulties required to compare use of hand hygiene at the 5 Moments with any other hand hygiene behaviour. They maintain that the provided evidence base, and subsequent successful take-up of the concept globally, provide support for hand hygiene as directed by the concept (Sax et al., 2012).

Finally, in support of the WHO 5 Moments, it is important to note that as well as being a training and promotional tool, the approach includes additional features to

allow hand hygiene compliance measurement, specifically focusing on performance at each of the Moments. The importance of measurement is discussed further, as is the importance of feedback (Chapter 5). What is essential to note is the ability of the WHO 5 Moments to form a part of this cycle of improvement.

2.5.5. Effective Hand Hygiene: Agent, Technique, Execution

Effective hand hygiene can be achieved through using the correct decontamination agent, correct technique and through execution at the correct points during Patient care to prevent cross-contamination. The WHO 5 Moments offers a standardised, transferable and measurable concept, into which training of technique and decontamination agent choice can be incorporated. These are linked specifically to evidence-based rationales identifying the importance of hand hygiene at each Moment. The key challenge, to be discussed in the next section, is to ensure compliance with such guidelines.

2.6. Hand Hygiene Compliance

Burke and Ockene (2001) offer two definitions for compliance within the healthcare sector. Firstly the term can be taken to mean *the degree to which an individual follows a specific recommendation* (pp. 26). With a more behavioural slant the authors cite the Haynes (1979) who defines compliance as *the extent to which a person's behaviour coincides with medical or health advice* (pp. 94).

2.6.1. Lack of Hand Hygiene Compliance

Despite the clear, evidence-based argument that hands can easily become contaminated through both Patient and environmental contact, there has been a wealth of data indicating that hand hygiene compliance amongst healthcare professionals is much lower than would perhaps be expected. Indeed, 40% is often cited as the average hand hygiene found in healthcare settings. This figure is identified by Bolon (2011) as traceable to an average adherence from 34 studies performed from 1981 to 2000, cited in Boyce et al. (2002, pp. S21).

2.6.2. Factors Affecting Compliance

In what the WHO (2009) refer to as a *landmark study* (pp.66) Pittet et al. (1999) used 2,834 observations to identify seven predicting variables of poor compliance to hand hygiene guidelines:

1. Hospital Ward
2. Type of Patient care
3. Intensity of Patient care (defined as the number of hand hygiene opportunities [HHO] per hour of Patient care).
4. Level of risk for cross-contamination (high-risk: before Patient contact or care or between a dirty and a clean site on the Patient; medium-risk: after contact with Patient or body fluid or after Patient care; low-risk: activity involving indirect Patient contact or hospital maintenance)
5. Time of day
6. Time of week
7. Professional Category

The WHO (2009) report on hand hygiene provides a comprehensive summary of literature into factors affecting compliance (Table A-1, Appendix 1a), allowing this issue to be explored at much greater depth than discussed here. A brief summary of studies relating to variables identified by Pittet et al. (1999) allows insight into the complexity of hand hygiene compliance, and the requirement to understand it as a multifaceted concept. Due to the existence of the WHO (2009) report, and differing objective of this thesis, the aim here is not to give a comprehensive overview of hand hygiene compliance. Instead key issues are to be raised for further discussion in terms of their relevance to the case study undertaken in this research.

a) Hospital Ward and Hand Hygiene: Intensity of Patient Care

Hugonnet et al. (2002) supported the findings of Pittet et al. (1999): that context of Patient care can affect adherence to hand hygiene standards. In their study, based over four ICUs within the 2,300 bed University of Geneva Hospitals, they used observational surveys to assess multiple factors affecting hand hygiene compliance. With reference to HHO, their data indicated a median HHO per hour score of 30 for nurses working within an ICU setting. This can be compared with the findings from Pittet et al. (1999) for nurses on a paediatric ward. The WHO (2009) report cites this as measuring nurses as having *an average of eight opportunities for hand hygiene per hour of patient care* (pp. 66).

Data from Pittet et al. (1999) demonstrates a difference between HHO in ICU and paediatric settings within the same hospital during the same observational period (across a sample of 48 wards of University of Geneva Hospital, December 1994). Their results show the average HHO per hour in ICU being 43.4, opposed to a

much lower figure of 24.4 in paediatrics. The impact on hand hygiene appears clear, with compliance found to be lowest in the ICU, at 36%, and highest in paediatrics, at 59%. The finding of hand hygiene compliance being lowest in the ICU was also found by Pittet (2000),a study which also confirmed that HHO were consistently higher in this setting than in a paediatric one (range in ICU of 297-529, compared to range in paediatrics during study 83-139). In this later study seven twice yearly observational surveys were carried out over a period of three years. This resulted in 2,629 observational periods netting 20,082 HHO from 833 hours and 52 minutes of data collection. The impact of context is further confirmed by the replication study of Pan et al. (2007) in an Italian hospital. They followed the Pittet (1999) model investigating hand hygiene compliance after high/low risk Patient care activities across differing units. Pan et al. (2007) also found much lower rates of HHO in paediatric wards, yet proportionally higher compliance than in other adult wards used for comparison (e.g. medical ward, surgical ward).

A further investigation involving Pittet (Pittet et al., 2003) found that in some settings the levels of HHO can reach extremely high levels. In the post-anaesthesia care unit studied (University of Geneva Hospitals, June/July 2000), the highest average level reached per Patient hour of care was recorded at 82 HHO, involving multiple healthcare professionals.

Such studies closely link the ward setting to intensity of Patient care, with a strong focus on the healthcare professional workload as an explanatory factor for levels of hand hygiene compliance. Whilst the majority of ward setting studies have focused on the intensive care/paediatric contrast, studies have also shown that a

specific ward speciality (e.g. surgical; Pittet et al., 2004) can have detrimental effects on hand hygiene. Hand hygiene compliance in Pittet et al. (2004) was found to be only 36.4% for those in the surgical speciality, compared to the highest finding in their study of 87.3% in the internal medicine speciality.

However, an alternate explanation relating to healthcare professional perception of risk has been offered to explain hand hygiene behaviour. A focus group study involving nurses was conducted by Efstathiou et al. (2011) to investigate factors influencing compliance with standard precautions. An outcome theme was that nurses saw Patients as cues of action for the use of standard precautions, with a marked difference between the reactions generated by adult and child Patients.

Adult Patients were described as high risk, whereas child Patients were seen as low risk. However the participants found it hard to quantify this reasoning in microorganism/infection potential terms, instead using a more emotionally driven explanation. Three direct quotes cited by Efstathiou et al. (2011) (pp. 7) illustrate the nurses' views of how their perceptions of Patients may lead to differing adoptions of standard precautions, including adherence to hand hygiene.

Firstly, a paediatric nurse described child Patients as: … *innocent creatures, well protected by their parents…unlikely that they have been exposed to a disease.* This is in almost exact contradiction to the description proposed by a nurse from the adult ICU nurse of adult Patients being: … *independent persons, there is much more chance for them to be exposed to and carry an infectious disease.*

The use of two separate participants to describe their perceptions of Patients may lead to criticisms of reliability on the grounds of individual differences. It cannot

conclusively be known what their views on the alternative Patient type would be (e.g. how the paediatric nurse viewed adult Patients). However, the following quote from an ENT (Ear, Nose and Throat) nurse provides a direct comparison of child/adult Patients from a single participant: …*it is easy to forget or not think of protection when you have a child in your hands. But it is different when you have an adult.*

The findings from Efstathiou et al. (2011) therefore suggest that the age of the Patient, split into child or adult broad categories, has an impact on hand hygiene. Perceptions from nursing staff were used to underpin hand hygiene behaviour. Thus, whilst workload has been used as an indicator for hand hygiene, determined by HHO the decision to translate these opportunities into behaviour may, in part, be down to judgements made by healthcare professionals based on perceived risk, as well as ability allowed through time.

Whilst the findings from Efstathiou et al. (2011) appear to counter the findings from studies cited in support of the workload hypothesis, a consideration of *intended* behaviour may provide an explanation. According to Efstathiou et al. (2011) it would be expected that higher hand hygiene rates would be found on adult Patient wards (i.e. ICU as mentioned by Hugonnet et al., 2002) and lower hand hygiene rates would be found on paediatric wards, as healthcare professionals infer less risk from child Patients, and therefore perform less hand hygiene. However it can be assumed that the higher workload in the ICU setting interferes with *intended* hand hygiene. A reduction in workload on the adult units may lead to significant increases in hand hygiene behaviour, according to the perception of risk hypothesis proposed by Efstathiou et al. (2011).

Should workload fall on the paediatric units, however, hand hygiene may not be seen to rise, as healthcare professionals may already be acting on their intentions and performing their desired level of hand hygiene, according to their perceived level of risk.

The potential for different triggers leading to different levels of hand hygiene compliance has already been discussed with regard to environmental contamination, and is explored further in Chapter 3 and Chapter 7. However, it is worth noting that the example here regarding the apparent decisions made based on perceived risk (from adult vs. child Patients) is central to the theory of Inherent and Elective hand hygiene (Whitby et al., 2006, 2007). The theory suggests that hand hygiene is not a homogenous behaviour that occurs solely due to rational decisions based on education or knowledge. Rather, some hand hygiene occurs due to instinctive, automatic reactions which may not have any relation to microbiological or visible stimuli, just a feeling or emotional need to clean hands after contact with a certain person, area or object. In the Efstathiou et al. (2011) study this may explain the difference between desire to perform hand hygiene during care of child and adult Patients. With adult Patients this emotional need is caused by perceptions of them being high risk.

b) Hand Hygiene and Level of risk for cross-contamination

In a similar thread the Pittet et al. (1999) study found healthcare professionals at their institution were less likely to execute hand hygiene when performing clinical activities categorised as high risk for transmission (cross-contamination). Conversely they were more likely to perform hand hygiene for those activities categorised as low risk for cross-contamination. Specifically they found

compliance rates for high risk activities ranging from 39% (before intravenous care) to 11% (care between dirty and clean body site). For low risk activities the range was from 63% (after contact with body fluid) to 58% (after wound care).

The authors, whilst commenting that this finding was *disturbing* (pp. 127) did not speculate on the potential reasons behind such an apparent counter-intuitive behaviour. As the study took place over a range of wards, as previously discussed, the Patient type and intensity of care may have influenced hand hygiene compliance at some of these specific activities. However the multivariate analysis conducted by the investigators found that element of risk was an independent predicting factor of hand hygiene compliance. An exploration of the types of activities categorised as low/high risk may explain this apparently unexpected finding. Themes of self-protection are perhaps linked more strongly to activities such as *after contact with body fluid* (low risk) than *before intravenous care* (high risk), despite the difference in risk of cross-contamination. Such themes are explored further in Study 3 of this research (Chapter 7).

c) Time of day/week and Hand Hygiene

The 1999 study of Pittet et al. also revealed variations in compliance depending on the time of day observations were conducted. Measured compliance levels were found to be lowest during the morning observational periods, compared with afternoon and night periods. They were lower on weekdays as opposed to weekends. As the same study also found activity index to have a significant impact on hand hygiene compliance, such patterns could be expected. This is due to the possibility that clinical duties are more prevalent during morning and

weekday periods, thus HHO rates would be higher, leading to reduced hand hygiene compliance.

A later study by Sahay et al. (2010) collected data on the effect of time of day on hand hygiene compliance. Based on a 34 bed ICU in a 650bed super specialty teaching hospital in India they used a six month prospective, observational method. Whilst they appear to erroneously attribute findings of lower hand hygiene rates at evenings and weekends to Pittet et al. (1999): *Pittet et al. [1999]…further highlighted that the compliance with hand hygiene was lower during evenings and on weekends*. (pp. 535), their own study allows direct comparison between hand hygiene on night and day shifts.

The setting studied afforded high opportunity to hand hygiene, with 1:1 ABHR dispenser: bed ratio, and approximately one sink to four Patients. Of note, the staff to Patient ratio remained constant regardless of day or night shift pattern. Therefore variable remained unaffected by time, though naturally Patient care duties can be expected to have differed.

The authors report that participants from all healthcare professional roles working on the unit were not aware of being observed. Observations were carried out discretely by a trained infection control professional using the same study protocol as Pittet et al. (1999): 30 minute observation periods randomly distributed during day/night hours during the six month research period. Hand hygiene non-compliance was determined by the act of leaving a Patient's bedside without decontamination, with three categories assigned thus: ‘‘*no hand washing done at all*,’’ ‘‘*improper duration of hand washing*’’ and ‘‘*no hand washing after procedure*” (pp. 536).

Overall compliance from the six month period, which included the observation of 5,639 hand hygiene events, was 59.99%, as only 3,383 events resulted in correct decontamination. With regard to time of day the reproduced Figure (Figure 2-9), split by professional category, shows hand hygiene compliance was significantly affected by time of day. Staff performed worse during the night than the day shift.

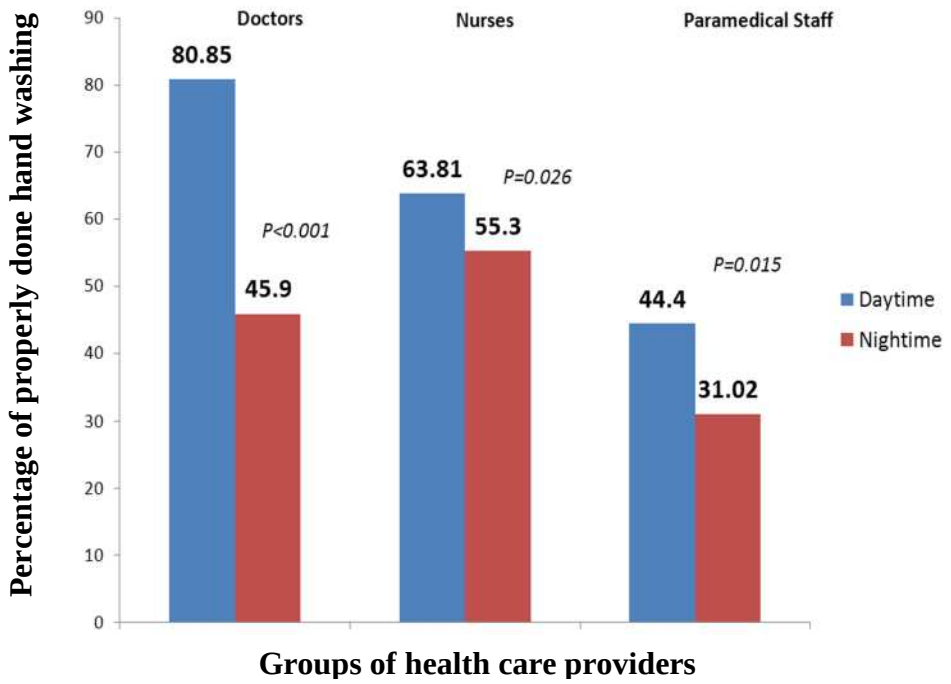


Figure 2-9: *Fig 1. Graph depicting the variation in hand hygiene compliance during day and night shifts in three groups of health care givers. Doctors showed highest variation in compliance during day and night shifts. (Reproduced from Sahay et al., 2010, pp. 538)*

Interestingly, in contrast to the majority of literature, that hand hygiene compliance rates fall as position in professional hierarchy increases, Sahay et al. (2010) found a higher rate of hand hygiene compliance in doctors than any other category measured: doctors 66.12%, nursing staff 60.71%, and paramedical staff 38.62%. However, this trend did not hold when separated over time periods, as can be seen in the Figure (Figure 2-9). Nurses had higher hand hygiene compliance than doctors at night. Indeed the difference between the rates of

compliance during the day and night was by far the greatest for the doctor participants. No suggestion was put forward by the authors to explain the day/night variation in hand hygiene compliance. Another study cited (Suzuki et al., 2002) postulates low staff numbers as a potential explanation, however here, as noted, staff to Patient ratio kept constant.

Erasmus et al. (2010) found time of day to be a factor studied in ten articles retained for further analysis in their systematic review of compliance to hand hygiene guidelines in hospitals (*N*=96). Of the ten the authors reported, six found time of day showed no effect on hand hygiene compliance rates (e.g. Watanakunakorn et al., 1998; Lund et al., 1994), whilst the remaining four showed mixed results (i.e. hand hygiene compliance greater in daytime: Earl et al., 2001; Venkatesh et al., 2008 vs. lower in daytime: Pittet et al., 1999; Duggan et al., 2008).

d) Professional Category and Hand Hygiene Compliance

The relationship between professional category and hand hygiene compliance can be split into two sub-sections:

a) Lower hand hygiene rates are found as hierarchy position increases
b) Other healthcare professionals can affect an individual's hand hygiene behaviour: the Role Model effect

i. Hierarchy (Role) effects on Hand Hygiene

Review papers comment that hand hygiene compliance has been found to differ depending on the professional category of those measured (Erasmus et al., 2010; WHO 2009; Allegranzi and Pittet, 2009).

The Erasmus et al. (2010) systematic review focused on hand hygiene compliance in accordance to guidelines within hospital care. It cites an overall finding that compliance rates were lower amongst physicians (32%) than nurses (48%). This 32% vs. 48% comparison stems from the reviewers finding nine studies which reported hand hygiene rates of >50% in physicians, as opposed to the same compliance rates in nurses being reported in 17 studies. The 32% and 48% represent the median scores from these reported findings. Table 2 (pp. 288) in their paper provides a comprehensive analysis of compliance rates for nurses, physicians, other healthcare professionals, and remaining groups of healthcare professionals where no clear definition was made in the original publications. From this table it is clear to see a difference in compliance rates between nurses and physicians. Of the six studies found to show over 71% compliance in nurses (Pittet et al., 2000; van de Mortel et al., 2000; van de Mortel et al., 2001; O'Boyle et al., 2001; Cromer et al., 2008; Duggan et al., 2008), only one of these also shows the same over 71% compliance rate in physicians (van de Mortel et al., 2001). The others finding 61-70% (Cromer et al., 2008), 41-50% (van de Mortel et al., 2000) and <20% compliance (Pittet et al., 2000). The remaining study, O'Boyle et al. (2001), which found between 71-80% compliance in nurses did not involve physicians, so no direct comparison is possible.

In only one study were doctors found to have a higher hand hygiene compliance rate than nurses at the >80 level (Muto et al., 2000). This observational study aimed to improve compliance through the introduction of an ABHR. At the baseline rate of compliance physicians had the highest level of compliance amongst co-workers at 83%, as opposed to nurses at 60%. Two months after an educational and motivational intervention, which facilitated the introduction of

ABHR dispensers, a follow-up evaluation occurred, and a significant drop in physician hand hygiene compliance was recorded. Compliance levels were measured at 29%, much lower than nurses, who this time measured at 67%. In discussion of their findings Muto et al. (2000) highlighted a major issue within healthcare which directly affects hand hygiene: the potential impact of healthcare staff hierarchies on behaviour. They observed that the high level of physician hand hygiene compliance at the baseline measurement period appeared to be due to high compliance of attending physicians. This was noted to be *followed in virtually every observation by compliance of the entire team of rounding physicians* (pp. 275). Conversely, during the follow-up evaluation phase this role model behaviour from the attending physicians appeared lacking. This behaviour was mirrored in that of their enlisted teams, with the authors noting that:

> *When other attending physicians exited rooms without washing their hands during the follow-up evaluation, none of their residents or medical students were observed to wash their hands.*(Muto et al., 2000, pp. 275)

The impact of role models on hand hygiene is well discussed (Pittet 2004; Sax 2007; Suchitra and Lakshmi Devi, 2007). A further example to illustrate the effect is that of Lankford et al. (2003), whose study suggests that the influence of co-workers can be so powerful as to overcome other intuitive infection prevention strategies, in this case the increased access to hand hygiene equipment.

ii. Hand Hygiene and the effect of Role Models

Lankford et al. (2003) concentrated on two key themes previously suggested as having an effect on hand hygiene compliance: 1) building design, which had received little empirical focus and 2) the effect of role models, the subject of the current discussion.

An old and new hospital facilitated the building design comparison. The aim was to determine whether a sink-to-bed ratio of 8:33 (haematology/oncology) and 4:23 (solid organ transplant unit) in the old hospital proved to be less beneficial for hand hygiene compliance than the situation in the new hospital. This new facility was a private enterprise where Patients occupied single-bed rooms inclusive of a dedicated sink for hospital personnel.

In their research hand hygiene was defined purely as an occurrence using soap and water. No other alternatives (e.g. alcohol gel) were made available throughout the research period. Hand hygiene was recorded (after room entry at the new hospital) using the APIC/CDC guidelines to identify when it should be expected (Centers for Disease Control and Prevention, 2002).There were two distinct study periods, the first lasting for 25 weeks (8th October 1998 – 29th April 1999), and the second lasting for 24 weeks (7th July – 23rd December 1999). During each research period a one hour observational period was conducted on every weekday, between 8am and 5pm, controlling for the previously outlined variables of time of day/week. Research period one took place at the old hospital, and research period two took place at the new (private) healthcare facility.

Prior to the empirical work beginning four observers (a physician, two IPC professionals and a microbiologist) were extensively trained regarding hand hygiene behaviours to look for, and how to undertake observational assessments. The observations were single-blind, the healthcare professionals at either facility were not informed of observers intentions. If asked the observers were permitted to explain that they were monitoring infection control measures. All healthcare professionals entering into the zones of observation (e.g. the Patient room) were

eligible for observation. No immediate feedback was given by the observer with regard to hand hygiene performed, or indeed not performed.

Overall 49 separate observations were performed, providing 45 hours of research material from 560 healthcare professional interactions featuring 729 HHO. The study found that when a higher ranking healthcare professional was present in the room and did not perform hand hygiene, other healthcare professionals in the room were significantly less likely to perform hand hygiene. Similarly, having a peer (a healthcare professional of the same rank) in the room that did not perform hand hygiene was also found to be an independent predictor of an individual's hand hygiene non-compliance. These two findings, that an individual appears influenced by the behaviour of those who are ranked higher, or equally, link to the findings of Donaldson and Carter (2005). They discussed the value attributed to role models in the learning experiences of nurses during their educational process. Donaldson and Carter (2005) found that individuals expected, once they entered the clinical setting, to seek direction from those around them, and monitor and modify their behaviour accordingly.

The apparent effect of role model influence was so strong in the Lankford et al. (2003) study that hand hygiene compliance was lower in the newly designed (private) healthcare facility compared to the old hospital, despite the 1:1 sink to bed ratio. The influencing factor of a higher ranking or peer presence within a room, who did not perform hand hygiene, appears to negate the (no doubt expensive) attempt to improve hand hygiene compliance by increasing access to facilities i.e. numbers of sinks.

Lankford et al. (2003) admit limitations. Being carried out over different seasons may have led to different demands being placed upon the two hospitals. Although the Patient: staff levels were felt to be equivalent, data to confirm this was only available for the ICU areas. Similarly, different staff had to be used for the comparisons, rather than moving staff from existing roles in the old hospital to the new (private) healthcare setting. Thus some changes in hand hygiene behaviour could be down to individual differences. However it is unlikely such differences would lead to statistically significant findings, such as found in the study.

As hand hygiene technique was not recorded in this study no data regarding efficacy of the hand hygiene being carried out by healthcare professionals can be commented on. It must also be considered that lower hand hygiene rates may have been observed when higher amounts of staff were in the room not due to the role modelling, but due to other observed but unrecorded factors, such as a medical emergency. Lankford et al. (2003) link this to the previously raised issue that time pressure has a detrimental effect on hand hygiene rates. However, again it is unlikely that such an issue would explain the study's statistical significance.

e) Factors Affecting Compliance: Summary

As discussed, these seven variables do not represent a fully exhaustive account of potential barriers to hand hygiene compliance. The WHO Table (see Table A-1, Appendix 1a) is testament to the wide array of additional factors identified by varying research designs. These additional factors include hand hygiene causing irritation to the skin (Huskins et al., 1999; Pittet, 2000), lack of knowledge (Suchitra and Lakshmi Devi, 2007) and perceived lack of institutional priority for hand hygiene (Pittet, 2001). These, and many of the other outlined factors in the

table, could be explored in depth. The theme being developed here, however, is to demonstrate the complexity of hand hygiene, to understand that it is a multi-dimensional facet with strong links to both contextual (i.e. setting) and behavioural aspects.

2.6.3. Factors Improving Compliance

For completeness the remaining section of the WHO (2009) table on hand hygiene compliance, highlighting research on factors found to influence good adherence/improved compliance can be found in Appendix 1b (see Table A-2).

The individual studies are not to be discussed here, nor are each of the factors to be examined in detail. However both the WHO (2009) report (section 16) and the Gould (2007b) Systematic Review (and later 2011 update) allow in-depth investigation of this topic, including critical assessment of studies/interventions to improve hand hygiene compliance. In brief the Gould (2007b) review found that whilst many interventions continue to be undertaken within the field of hand hygiene to attempt to improve compliance rates, the methodological quality of the vast majority require significant improvement. There is an acceptance that whilst randomised-controlled trials (RCT) may be unsuitable, interrupted-timed series (ITS) designs with at least a 12 month follow-up period may offer a feasible starting point.

Research into hand hygiene compliance has produced two-sided findings: factors that are both detrimental and beneficial when attempting to achieve compliance to hand hygiene guidelines. What is particularly useful with the WHO (2009) table (Appendix 1a, 1b), and revealing from a second Gould (2007c) review, is the

additional detail regarding how such factors have been discovered. Namely, within the field of hand hygiene compliance different tools of measurement are often used. These in turn may be argued to affect the perceived reliability and validity of the study outcomes. The next section addresses the measurement of compliance, a central theme of the current case study.

2.6.4. Measurement of Compliance

To understand the impact of any hand hygiene intervention on compliance rates at a healthcare setting, first those carrying out the work need to know their current benchmark. Thus accurate measurement is of vital importance.

Haas and Larson (2007) provide a review of hand hygiene compliance measurement, using a literature review resulting in an in-depth review of 31 articles from a wider relevance scanned pool of 662. Three predominant measurement methods emerged: direct observation, self-reporting, and indirect measurement (via product usage or electronic monitoring).

Of these the authors note that direct observation is considered the gold standard by the WHO. This rating is widely cited, including by Bolon (2011), Boyce (2008, 2009) and the Joint Commission (2009). To understand the preference for this approach, the advantages and disadvantages of the other two main measurement methods highlighted, self-reporting and indirect measurement, are worth briefly considering, before assessing direct observation in more detail.

a) Self-Reporting as a measurement method for Hand Hygiene

In the WHO (2009) *Guidelines on Hand Hygiene in Health Care* report, it is acknowledged that self-reporting can be used to monitor hand hygiene compliance; however the comment is made that:

> *It has been demonstrated, however, that self-reports of compliance do not correlate well with compliance measured by direct observation, and self-assessment markedly overestimates compliance with hand hygiene.*(pp. 159)

Self-reporting does, though, offer a significant saving of resources, as no additional individuals or equipment are required for data collection. However Haas and Larson (2007) advise caution with regard to validity. Haas and Larson cite Moret et al. (2004), who used self-reporting of hand hygiene as a comparison with direct observation. Using 25 different units at a University Hospital in France, the study findings demonstrated a major flaw in the approach. Categories of participants, physicians and nursing attendants were found to be significantly over-estimating their hand hygiene rates, whilst nurses under-estimated their compliance. Tibballs (1996) also noted discrepancy in compliance rates, finding a stark difference between self-reported hand hygiene rates of doctors (73%) compared to that from observations performed during the same period (10%).

Larson et al. (2004) recorded the number of gloves, hand washes, uses of ABHR, and approximate time spent wearing gloves. Participants or researchers filled in identical diary cards, to allow either self-report or direct observation as tools of measurement. Methodological issues prevent a full comparison on validity between direct observation and self-reporting, as the diary card collection period and direct observation period did not necessarily overlap. Therefore accuracy, what level of hand hygiene actually occurred, could not be determined. An

improved design may have included individual identification, allowing a participant to be observed and their own self-reported hand hygiene score for that period to be compared with the data collected by the researcher observing. However due to the use of anonymised data this was not possible here. What can be seen from the Larson study is that the overall reporting of ABHR use from the nurse participant diary cards (self-reporting) was significantly higher than the figure recorded by direct observation (mean 1.55 vs. 0.98). This was the opposite for hand hygiene performed at the sink: self-reporting was significantly lower than that recorded by direct observation (mean 1.24 vs. 1.86). Discussed in more detail in the next chapter this finding may suggest a heightened awareness by healthcare professionals for hand hygiene behaviours which are specific to the workplace (e.g. use of ABHR). This awareness may be over and above that which is seen as automatic, or every day, community based (e.g. sink use).

Elridge et al. (2006) employed both observation and self-reporting to measure the impact of five Six Sigma interventions on hand hygiene. The authors found that the already high levels of compliance self-reported by participants did not change significantly throughout the study: 87.8% pre-interventions, 86.5% post-interventions. This was in comparison to the compliance rate measured by observation, which was much lower at the pre-intervention stage (47%) and rose to 80%. This discrepancy infers that participants routinely and consistently over-estimate their hand hygiene compliance rates. The authors note that this makes it much harder to communicate the need for change in hand hygiene practice. Individuals may already feel they are performing highly within this given area. This may also be the case when assessing the type of hand hygiene being performed. It has been seen that hand hygiene with ABHR appears more

susceptible to over self-reporting than that using sinks, which appears under-reported (Larson et al., 2004).Interventions aimed at increasing hand hygiene with ABHR may therefore be met with confusion, even resistance, as healthcare professionals may perceive their hand hygiene in this area to already be high.

To summarise, Boyce (2011) reviews the literature within this field, reaching the same findings regarding inconsistencies between participant estimations of compliance and findings from direct observational studies: …*experts do not currently recommend the use of self-reporting methods as a primary method for establishing compliance levels.*(pp. 4)

b) Indirect Measurement as a measurement method for Hand Hygiene

Indirect measurement calculates how much product (e.g. ABHR, liquid soap, paper towels) has been consumed to establish hand hygiene rates, often over a set time period. This is often expressed as hand hygiene events per 1000 Patient-days (Boyce, 2011; Pittet et al., 2000), or Patient care/bed day (Larson et al., 2005; McGuckin et al., 2009). Rates can be used as benchmark figures, the impact of interventions assessed by re-measurements of product usage. Increases in product usage are usually taken as positive indicators for an intervention under evaluation.

Product measurement can be used in conjunction with measurement using direct observation (Eckmanns et al., 2006; Pittet et al., 2000). Boyce (2011) found that 77% (10/13) of studies in his review found observed compliance rates increased in line with increased of ABHR. In their summary of hand hygiene literature the WHO (2009) report mixed results regarding findings from indirect measurement compared to direct observation. Whilst citing, in agreement with Boyce (2011),

studies that show correlations, (Bischoff et al., 2000; Pittet et al., 2000; Hugonnet et al., 2002), they also cite those that do not (van de Mortel and Murgo, 2006).

The van de Mortel et al. (2006) study allows the apparent discrepancies between outcomes using alternative measurement methods to be seen clearly. Their four-phase intervention study returned markedly different results from product and observational measures. After measuring a baseline in an initial month period, three further monthly periods of measurement were carried out in conjunction with interventions aimed at increasing hand hygiene compliance (e.g. including written reminders, new starter orientation, Patient participation). Of interest here is the results showing that whilst all three intervention phases showed increases in product usage, the hand hygiene adherence measured by covert observation actually fell in phase two, before rising again in the last two phases.

This finding suggests that in phase two at least it would be hard to link the rise in product usage to a rise in hand hygiene at the specific times/moments deemed appropriate for measurement for direct observation. As the authors note, this may suggest that direct observation has a weakness in not being able to capture all moments of hand hygiene. Therefore direct observation under-estimates how much hand hygiene occurs, represented more by the increase in product usage. However, of particular importance when looking at adherence to specific moments of Patient care (e.g. the 5 Moments) is the limitation of indirect (product) measurement of obtaining information about the *appropriateness* of incidents of hand hygiene product use. It is impossible to know for what purpose and in what context the measured product has been used. For example, an increase of 50% product usage over a study period cannot guarantee that hand

hygiene is correctly being carried out according to specified guidelines unless other monitoring activities are conducting in parallel e.g. direct observation. This issue is highlighted by both the WHO (2009) and the Joint Commission (2009).

This issue may be overcome with a move towards electronic tools to aid indirect monitoring, whereby specific areas of care are monitored and hand hygiene compliance is measured, with data being collected for analysis. These systems are discussed in detail in Chapters 3 and 6, thus will not be discussed in-depth here. However, electronic tools have been used to aid measurement using indirect methods through, for example, automatic counters within ABHR or liquid soap dispensers (Larson et al., 2005; Kinsella et al., 2007; Marra et al., 2008).

c) Self-Reporting and Indirect Measurement: Advantages and disadvantages summary

The respective advantages and disadvantages of the alternative methods to direct observation, self-reporting and indirect measurement, are summarised in Table. The next section examines in more depth the use of direct observation as a measurement tool for hand hygiene compliance, examining its respective advantages and disadvantages, before outlining the need for systematic measurement within the field.

Table 2-1: Summarising advantages and disadvantages of alternatives to gold standard of hand hygiene measurement (direct observation)

Method	Advantages	Disadvantages
Self-Reporting	• Non-labour intensive • Large sample size possible • Can use diary cards to reduce recall decay[8] • Can identify individuals (wards, units etc.)	• Poor reliability/validity (linked to over/under reporting) • Sampling Bias (studies may only select certain professional categories, shift patterns etc.) • Non-standardisation of methods make cross-comparison of findings difficult • Cannot assess hand hygiene technique
Indirect Measurement	• Non-labour intensive • Large sample size possible • Can measure at ward/unit levels • Sampling Bias removed (can run 24/7)	• Cannot identify individuals • Cannot link to appropriateness of use (e.g.at Patient care moments) • Mixed results on validity when compared to observed findings • Cannot assess hand hygiene technique

d) Direct Observation as a measurement method for Hand Hygiene

Having briefly reviewed the advantages and disadvantages of the alternative two main methods of data collection for hand hygiene compliance the third option, already noted as being hailed as the gold standard, is now to be assessed.

Observation can be overt, where no attempt is made to conceal either the data collection or the reason for data collection (i.e. that hand hygiene data is being collected), or covert where various means may be employed in order not to

[8]e.g. hand hygiene can by recorded 'as and when', as in the prospective study of Larson et al. (2004), rather than retrospectively after the event

disclose that hand hygiene data is being collected. The WHO (2009) give detailed guidance for carrying out an ideal observation method (e.g. Part III, section 1.2, pp. 159). This covers the need for trained and knowledgeable observers, a clear evidence-based objective and observation form, and precise methods of data analysis. However, as this next brief summary on advantages and disadvantages of the method as a whole will determine, there are still limitations.

i. Advantages of Observation

The WHO see direct observation as the gold standard for the measurement of hand hygiene (WHO, 2009; Boyce et al., 2002). They argue it provides the only method allowing information to be gathered regarding the number of HHO occurring, the context in which these HHO arise, and the ways in which hand hygiene could be correctly applied within the specific sequence of care being monitored. Thus any resultant data could be fed back using the same context, vital for effective training and learning opportunities. This is unlike indirect measurement, where the data is unrelated to context, and self-reported measures which may be open to over/under estimation of actual hand hygiene behaviour. This is also highlighted by Haas and Larson (2007), who confirm that a particular advantage of direct observation is the ability to …*pinpoint areas of strength or weakness in HH* [hand hygiene]*behaviour* (pp. 7).

Of particular importance in settings where a variety of decontamination options are available (e.g. ABHR and soap and water, as in most NHS settings) is the ability of direct observation to determine whether the selected option is suitable for the Patient care activity performed. For example, exposure to a CDI Patient must result in hand hygiene with soap and water, not ABHR (Department of

Health, 2007). Indirect measurement would be unable to provide this information, and self-reporting may be unreliable if the individual was unaware they had made an incorrect or inappropriate decontamination choice, or if they failed to enter the correct preceding activity. This relates strongly to the ability of direct observation to be able to assess hand hygiene technique (Haas and Larson, 2007), a limitation of the previously discussed data collection methods (Table 2-1). Reviews reveal this advantage appears seldom exploited in favour of observations based on frequency (Erasmus et al., 2010; Haas and Larson, 2007). However the opportunity is at least available for data collectors to objectively assess the efficacy of the hand hygiene practice being observed, ideally comparing it to evidence-based guidelines to ensure effective hand hygiene (WHO 5 Moments, Ayliffe technique).

ii. Problems with Direct Observation

1) Labour Intensive

A striking limitation with the use of direct observation stems is how labour intensive the method is, accepted even by the WHO (2009) whilst they uphold it as the gold standard measurement technique.

Using their example (pp. 158) of typical average hand hygiene density being 10 HHO/hour they explain that it would thus take a total observation time of 50[9] hours to collect data on 500 HHO. This would be further complicated and labour

[9] Original source – pp. 159 (WHO 2009) states *"For example, with a typical average density of 10 hand hygiene opportunities per hour, a total observation time of 80 hours is required to obtain 500 opportunities."* However, this does not appear to make mathematical logic, and in the absence of reference to the source, or further explanation as to addition of possible time for validation checking or extra procedures, the assumption has been made that the "80" value should read "50".

intensified if the desired HHO sample were to be as representative as possible, taken from a wide range of professional categories, shift patterns and healthcare settings. To be representative the sample sizes would be required to grow, as discussed shortly, creating a greater overall observational time for the data collection period. In the systematic review of Erasmus et al. (2010) they found that whilst there was vast variation in sample size (number of observations) the majority of studies (*N*=76) based their findings on between 500–1,500 observations. This would infer, using the WHO (2009) example, a labour investment of between 50 – 150 hours for data collection for each sample size.

2) Observation Bias/Hawthorne Effect

The effect of being observed can lead to changes in hand hygiene behaviour, often skewing results in favour of higher rates of hand hygiene compliance (Eckmanns et al., 2006; Kohli et al., 2009). It can also potentially lead to unnecessary hand hygiene at moments not linked to ensuring safe Patient care (WHO, 2009; Bolon, 2011). In a two period observational study by Eckmanns et al. (2006), set in five ICUs within a 2,200 bed tertiary care university hospital in Berlin, healthcare professionals were initially observed performing hand hygiene without explicit knowledge (covert period). A repeat session followed where they were told in advance that they were to be observed (overt period). All observations were made with regard to the use of ABHR for hand hygiene, and details regarding healthcare professional category and before/after procedure compliance were collected. In respect to the Hawthorne effect, specifically study objective, Eckmanns et al. (2006) found a 55% compliance increase when the observation was made known to the healthcare professionals (the overt phase) compared with the covert stage.

Interestingly the authors also comment that compliance levels were higher in the overt phase even though this phase was characterised by an increased level of procedures per hour of Patient care. This is despite workload already being shown as an independent predicting factor negatively affecting compliance rates. This suggests that the presence of known observers, the Hawthorne effect/observation bias, may be significant enough to overcome other limiting factors to hand hygiene, for example intensity of Patient care. On the one hand this appears a positive solution, if the objective is to ensure that hand hygiene rates improve, increasing Patient safety. However, another implication is that data collected using overt observation may not be a true reflection of the behaviour exhibited should overt observation be removed, especially considering other contextual factors e.g. intensity of Patient care.

Whilst covert observation may reduce the Hawthorne effect, by removing the observation bias and potential elements of "performance" from the healthcare professionals being studied, it may lead to distrust amongst those from which the data is collected once the observation is revealed (WHO, 2009). This may have further negative effects should the data be the basis for future hand hygiene improvement interventions. These are often found to be most successful if launched in a culture of positive teamwork, where shared goals and motivation for change are strong drivers (for example, in SICU, Earl et al., 2001). Kohli et al. (2009) further studied the impact of overt and covert observation on healthcare professional hand hygiene. They concluded that whilst it may be useful to explore the use of covert measures in areas where high compliance is the usual standard, areas of known low compliance appear to be less vulnerable to observation bias effects.

Bolon (2011) also discussed the issue of ecological validity (see 2.2.2.), whereby the results of hand hygiene compliance studies may be affected by their experimental setting. In the example she gave it is the research issue of observer effect that may cause the problem, with the *concern that these studies may also not reflect real-life hand hygiene behaviors because the participants knew they were being studied* (pp. 27: citing specifically Boyce et al., 2002; Girou et al., 2002; Pietsch, 2001).

It is important to note that it is not only the participant's behaviour that can skew results, but also that of the data collectors. Observer bias, defined by WHO as *systematic error introduced by inter observer variation in the observation method* (pp. 159) must be addressed through training and validation exercises (e.g. parallel observations and inter-rater reliability cross-checking), although these standards need to be regularly refreshed to ensure that individual bias may not unconsciously alter the observers stance over time.

3) Selection Bias

In an ideal scenario direct observations would be carried out using randomised samples, drawn from pools which represented the entire healthcare setting being studied, including all professional categories of staff, all units of care of interest, and carried out over all periods of care (i.e. 24 hours a day). However, due to the previously discussed issue of labour intensity direct observation is often only a snap shot method. This selection bias may also be influenced by accessibility, for example observers may only be available/allowed access on certain days, shifts and to certain areas. As time of day and ward context have already been discussed as having independent influences on hand hygiene compliance such

inability to provide more representative observation may further skew reported findings. In the comparative observational study by van de Mortel et al. (2006) the authors estimated they only managed to observe 0.4% of the total HHO occurring within the unit during the month deemed *best*. This classification was based on observations achieved. The 0.4% finding stemmed from an understanding of the 'snap-shot' nature of the observational method, which by design infers that many other hand hygiene events occur during periods of non-observation. This is in addition to realising that routinely many events are likely to occur in areas not visible to the observer e.g. behind Patient curtains.

4) Sample Size

As discussed earlier whilst it is desirable to have a representative sample, to avoid selection bias, the issues regarding labour intensiveness and accessibility can hinder the ability of the data collector to fulfil such desires. Certainly the findings from Erasmus et al. (2010) suggest there are wide variations within the field of direct observation when it comes to sample size. Between seven and 1,050 healthcare professionals made up the sample size groups returned in their systematic review, with between 19 and 20,082 observations carried out across the selected studies. The authors also commented that the majority of studies (*N*=56) failed to mention the actual number of healthcare professionals observed, the standard reporting measure usually the number of observations. Thus there is a lack of uniformity as to what constitutes the "sample" when using observation. Lack of reporting details such as professional category further reduces the ability of cross-study comparison. The section on sample size in the WHO (2009) report (pp.159) allows specific consideration to be taken as to the statistical significance

of sample size, yet observational study samples are often too small and research designs too weak to successfully meet such criteria (Gould et al., 2007c).

iii. Evaluation of Direct Observation as a Measurement Tool

Gould et al. (2007c) provide a wide ranging review of hand hygiene compliance methods. Their main objective was to evaluate studies that have used direct observation, yet their inclusion criteria allowed for studies using methods alongside observation, therefore the review also examines research using self-reporting and indirect measurement. It is beyond the scope of the debate here to present the findings of the in-depth review, suffice to say the authors found fundamental flaws with regard to rigour used in the design of studies returned from their search criteria. These included issues with 1) scope: e.g. high tendency to focus on hand hygiene frequency over efficacy; settings often limited to single units rather than a range of contexts; participant populations often drawn from single healthcare professional category, and 2) validity and reliability of data: e.g. studies predominantly poor in detailing how data collectors were trained; how detailed data was collected in-situ; whether inter-rater reliability was considered or addressed.

In the systematic review by Erasmus et al. (2010) only 17 studies (out of 96 papers passing inclusion criteria) reported any reliability testing with regard to the procedure they used when performing direct observation. However the authors comment that this small minority did show good reliability results (Cronbach alpha >0.7). Their review also revealed the myriad of methods and research designs used when employing direct observation (and in some cases self-reporting in parallel). These included the use of individualised observation forms, vast

variances in sample sizes, and differences in both Patient care activities and professional categories being observed. Such variations make comparisons between resultant compliance rates from studies very difficult. In their review paper Braun et al. (2009) attest to the limitations of current measurement methods for hand hygiene. They also highlight lack of standardisation across study design methods leading to difficulties in making meaningful comparisons either between settings, or within settings over different time periods.

Alongside this, and the two reviews by Haas and Larson (2007) and Gould et al. (2007c) the conclusion appears to be that whilst direct observation may currently be the most desirable method for collecting hand hygiene data, it is by no means the ideal solution. The documented flaws, summarised here and discussed in detail elsewhere (McAteer et al., 2008) indicate a need for a more systematic approach to measurement. This would allow accurate, comparable and less labour intensive data collection on this vital Patient safety practice.

e) Systematic measurement for Hand Hygiene

The application of measurement for hand hygiene at a more systematic level, as opposed to individual studies can be explored through the evolving topic of auditing, which has risen in prominence within healthcare over the past 15 years. As part of the national Clinical Governance Framework (Starey, 2001) Clinical audit is seen as a key parameter to ensure quality Clinical care. Within this domain the measurement of hand hygiene compliance has not been ignored.

2.7. Quality Management and Auditing

The need for hand hygiene compliance has been established in the earlier sections of this thesis, through an exploration of the links in the Chain of Infection. However the previous section demonstrated how this process is often not practiced to required standards. To investigate the scope of this failing in adherence to standards, and to assess the impact of interventions introduced to improve hand hygiene compliance, accurate measurement tools are required. Nonetheless, the difficulty in measuring hand hygiene has been highlighted. Auditing tools offer a way to standardise measurement, using robust, validated and objective instruments which allow collected data sets to be compared alongside other data sets generated using the same tools. This section explores the concept of Quality Management (QM) and auditing in brief, then specifically addresses their application to the context of hand hygiene and how this links to the case study site selected for the current research.

2.7.1. Quality Management

The QM movement is predominantly seen as emerging from Japan during the 1950s (Moen and Norman, 20??,pp. 5-10). Often conceptualised through the use of the terms Quality Improvement (QI) and Continuous Improvement (CI), QM employs tools designed towards continual incremental improvement, to achieve specified objectives (Powell et al., 2010).

Walley and Gowland (2004) note the influx of “process redesign tools” adopted by the NHS from both manufacturing and service organisations. In their narrative review of QI models in healthcare Powell et al. (2010) note that Total Quality

Management (TQM) and Continuous Quality Improvement (CQI) are often applied as catch-all labels for general QM interventions, over and above other approaches explored (e.g. Lean, Six Sigma). Where TQM could be identified as a clear approach (Joss and Kogan, 1995) financial savings were found to be possible, however Powell et al. note a number of problems. These included obtaining corporate support for a quality approach, standards of measurement used, a low inclusion rate of clinical staff in TQM interventions, and a lack of integration between TQM initiatives and audit processes. A systematic review by Nicolay et al. (2011) found strategies applied to surgical settings used a variety of methods under the QM umbrella, including Six Sigma, CQI, Plan-Do-Study-Act/Plan-Do-Check-Act Cycles, TQM, Lean, and Statistical process/Quality control (SPC, SQC). They summarise the vast potential for such methods to be applied within the surgical healthcare sphere, however conclude that current interventions reported in the literature are limited by poor quality study design.

2.7.2. Quality Management Applications to Healthcare

Gill et al. (2011) document the formation of a QIT (Quality Improvement Team) in 2003, tasked with reducing neonatal HCAI within a unit caring for 80+ infants at any one time. An initial priority was to follow the evidence–base supporting the use of ABHR to increase hand hygiene. Access to ABHR was vastly increased at prominent areas within the unit, including at point of care (i.e. infant cots). To monitor effectiveness, observational tools were designed to measure hand hygiene, with data being fed back to unit staff. Other interventions, including those to improve practice involving central lines, peripheral intravenous catheters, blood culture handling and overcrowding were also addressed using evidence,

monitoring and feedback by the QIT. Effectiveness of the QIT formation and intervention was established by statistical analysis of neonatal HCAI over a 7 year study period (2003-2009) during which time 990 infants were admitted to the unit. The paper presents compelling evidence for a steady decline in neonatal HCAI over this period. Fundamental to their approach the authors support the use of clear charting to communicate progress and engender support and enthusiasm for the required continuous change needed to achieve maintained improvement.

A CQI approach is the subject of study for Wall et al. (2005) who outline the background problem of high rates of catheter related bloodstream infection (CR-BSI) in their setting of a medical ICU (MICU). The study objective was to establish whether real-time measurement of CVC (central venous catheter) insertion was feasible within MICU settings, this initial step being crucial to enable CQI steps to reduce CR-BSI rates. A checklist was ultimately designed and trialled based on a refined version of existing processes within the MICU. This included hand hygiene, the need for adequate supervision of trainees, correct use of sterile barriers (e.g. personal protective equipment [PPE]), the use of chlorhexidine and a detailed context as to CVC insertion circumstances (e.g. emergency or standard). The authors noted that the checklist, as well as being designed for measurement, served a duel purposes, with a secondary role as an intervention due to its ability to create a reminding presence for those involved in CVC care. Alongside the checklist the advantage of multifaceted interventions was further exploited by the implementation of education and audit and feedback programmes.

Data was collected for a two year study period (2002-2004), capturing the insertion of 360 CVC. Analysis of individual factors on the checklist (e.g. use of sterile barriers) allowed further investigation of specific trends and targeted responses to be developed. Resultant trends were analysed in return. The CR-BSI level measured at the end of the study period was found to be at a historically low level for the unit. However the authors comment that they perceived the development and adoption of the CQI approach to be the bigger achievement. Key to this belief was the performance of unit staff, who moved from being reactive, driven by clinical requirement when faced with poor performance, to being proactive, looking for ways to improve performance, trial potential improvement methods and assess outcomes.

Both these examples, of Gill et al. (2011) and Wall et al. (2005), are small scale, individual site studies. They are included not to purport to be representative of all QM work in the area of healthcare, nor even of work within their specific fields, but to show the potential for QM (incorporation QI and CI) within individual, context defined healthcare settings.

Essential for success in both cases, and in all settings, is strong leadership, clear goals, and a systematic approach to establish the need for change, and the effects of any implemented intervention (Powell et al, 2010). The regular collection and analysis of data is seen as a key QI activity, whichever QM approach or tool is adopted, to assess performance of both individuals and processes implemented (Powell et al., 2010).

2.7.3. Auditing

QM as an umbrella field offers a toolbox of approaches and methods, of which audit is firmly established as a core element. Audit can be adapted to best suit the setting for which improvement is required. A plain English interpretation of the terms and definitions section of the 2011 International Organisation for Standardisation (ISO) 19011 offered by Praxiom.com (2013), defines audit as:

> *…an evidence gathering process. Audit evidence is used to evaluate how well audit criteria are being met. Audits must be objective, impartial, and independent, and the audit process must be both systematic and documented.*

Crucial to the process of audit is the need for clear criteria against which to evaluate collected data, and the need for impartiality on behalf of those involved in amassing the audit data. Following their definition, a further distinction is made depending on where the auditor (individual/s carrying out the audit) is based or originates from: internal, from within the same organisation, or external, from a separate organisation, an independent body or a regulatory body.

In healthcare, auditing is often defined as "Clinical audit", and is seen as a way of ensuring that not only is the right thing being done, but it is also being done in the right way (Benjamin, 2008; Smith, 1992). Powell et al. (2010) attribute the notable presence of auditing within healthcare, in part, to a significant drive towards seeing clinical audit as a vehicle to drive QI during the 1990s. Benjamin (2008) further outlines the process of audit in a healthcare setting, identifying three main strands it may investigate: Structure of Care, Process of Care and Outcome of Care. Within the UK the process of clinical audit is used as a tool to ensure "Quality Care for Patients", through being part of the Clinical Governance framework. Quality Care, the goal to which clinical audit is applied to achieve

within healthcare, can be seen to draw similarities from QM. Both possess the conceptual desire to drive improvement throughout the organisation, involving those within the organisation whilst considering the needs of the "consumer" (Patient). As discussed auditing has successfully been used in healthcare settings as part of QI interventions, including reduction of neonatal HCAI (Gill et al., 2011) and real-time measurement of CVC care in adult MICU (Wall et al., 2005).

2.7.4. Auditing within Hand Hygiene

Measurement in hand hygiene, usually employing either self-monitoring, in-direct measurement or direct observation (or a combination) is required to allow baseline compliance rates to be established prior to interventions being launched. This allows the efficacy of these interventions to be gauged. Observational methods also allow contextual data about hand hygiene to be collected, allowing further opportunities for improvement to be gained. For example observation may allow potential barriers to hand hygiene and specific workflow patterns to be recognised. However, as has been established, no methods are without limitation. Kilpatrick (2008) comments on the commonality of auditing as a method for monitoring hand hygiene, referring further to the existence of a number of differing tools existing for this purpose. Auditing offers the opportunity for systematic data collection, with a set purpose and meaningful objective as to how to use the data to improve future practice. For hand hygiene this may be the development of a new initiative, specific interventions within one ward, or with specific individuals. Here three examples of existing tools are briefly presented to attest to the current role of auditing within the field of healthcare hand hygiene measurement.

a) Health Protection Scotland

Health Protection Scotland produced a tool to enable mandatory auditing in Scotland as part of their multimodal national hand hygiene campaign (Kilpatrick, 2008). This tool, including both electronic and paper components, was devised through rapid review of existing audit tools, and incorporation of current guidelines relating to hand hygiene technique (i.e. images including WHO 5 Moments). A full outline of the development of the tool is provided by Kilpatrick (2008), which fully explores the rigour and levels of review required to develop a working audit tool suitable for widespread use. Training days were held to aid Local Health Board Co-ordinators (LHBCs) and IPC staff to use the tool, which ensured a standardised method would be used throughout the proposed audit period. Such training sessions also allowed for the tool to be tested with healthcare professionals, whereby feedback could be gathered as to,(for example) its ease of use. The audit tool was trialled through the execution of a widespread audit of hand hygiene compliance across NHS Scotland during a defined national audit period (9-20thMarch 2009), with protocol details and findings published by Health Protection Scotland (HPS, 2009).

Whilst accepting the limitations of audit involving observation (e.g. observer bias, selection bias, observation bias) the conclusions from the review of the first bi-monthly report on hand hygiene compliance, using the new audit tool, were positive (HPS, 2009). It was possible to collect data from a wide source at a national level, and provide analysis based on areas for further investigation, such as NHS Board and professional category. Such analysis allows for more specific,

rigorous research to be directed, bridging the gap between audit and research (Smith, 1992).

b) WHO Hand Hygiene Observation Tools

On a global scale this overview discussion of hand hygiene audit tools would not be complete without an acknowledgement of the widely tested and used WHO tools for calculating hand hygiene compliance. As part of a guide for implementing their multimodal hand hygiene improvement strategy (WHO, 2009d) specific tools have been developed to allow for standardised, methodical evaluation and feedback (pp. 22 – 26 in Guide).Of particular relevance to this discussion are the *Hand Hygiene Observation Tools*, consisting of an Observation Form (WHO, 2009b)(designed to be used for observations of hand hygiene within routine care practices) and two Compliance Calculation Forms (WHO, 2009b). Rather than being standalone tools, these are intrinsically linked to the methods and educational themes within the multimodal WHO approach. This allows users understanding as to context of the hand hygiene they are observing. This knowledge is also important once the data has been collected and calculated, as it can be used as a basis for feedback and dissemination, and in turn further education and training. Furthermore, both components of the *Hand Hygiene Observation Tools* (Observation and Calculation) are complemented by an over-arching "Hand Hygiene Technical Reference Manual" (WHO 2009e). The manual ensures all observers have access to the same level of instruction on how to use the tools, helping to reduce observer bias. This can lead to a greater chance of validity in cross-comparison of collected data.

c) ICNA Hand Hygiene Audit Tool

The ICNA Hand Hygiene Audit Tool (Appendix 1c) is part of the wider ICNA (2004) "Audit Tools for Monitoring Infection Control Standards 2004"document. It consists of 40 points, separated into 32 alphabetised questions, allowing assessment of environmental factors (e.g. availability of hand hygiene equipment, including paper towels, soap and ABHR), observational factors (e.g. whether hand hygiene is performed at key moments of Patient care) and knowledge factors (e.g. whether healthcare professionals are aware of when they should be performing hand hygiene).

The tool is designed to be used by trained individuals using observation; however the overt/covert nature of this method is open to interpretation and personal choice. This may have a bearing on the behaviour of those individuals being studied, as discussed previously. This issue is addressed in Chapter 5, when this method is explored in full at the case study site during interviews and participatory observation.

Alongside the manual observation stage of the ICNA (2004) tool, a standardised, ready to use Microsoft Access database allows observed data to be translated into compliance scores. These are categorised into Compliant (85% or above), Partial Compliance (76-84%) and Minimal Compliance (75% or less) ratings. This rating can then be used for further action and reporting purposes. The tool, whilst enabling data to be collected according to a standardised framework, has an apparent imbalance in focus on environmental factors rather than actual observed hand hygiene behaviour, demonstrated with 20 questions attributed to environmental and only seven to observation. Thus a ward with full soap, paper

towel and ABHR dispensers, exhibiting clean sinks, could score well on an audit, even if no one performs hand hygiene correctly. This is opposed to a ward where all hand hygiene observations are correctly observed, yet some ABHR or soap dispensers may be empty. However, it must be remembered that this tool was developed at a time when data regarding hand hygiene was collected in a very ad-hoc manner, if at all. This tool offered a relatively simple way to collect data which could be used to begin to make benchmark comparisons, both across settings, and across time spans as interventions were rolled out.

In 2008 IPS (previously known as ICNA) published a report documenting their findings from a questionnaire review of users of their suite of ICNA Infection Control audit tools, including the hand hygiene section. The data returned came from 148 completed questionnaires (102 hospital/46 community settings), predominantly from England, although all UK countries, ROI and a respondent from Gibraltar were represented. In terms of hand hygiene 73% of those using acute tools (hospital setting) reported use of the ICNA (2004) hand hygiene tool. Whilst further individual data about the hand hygiene tool is not reported, the overall feedback about the ICNA (2004) audit tools is generally positive, with the section on *Themes arising from use of the ICNA Audit Tools* citing:

> *The tools were described as comprehensive and easy to use, providing clear national standardised evidence based criteria for monitoring practices and the environment.*
> *Respondents indicated that the wording of some criteria caused confusion and required review and that the 2004 tools were too long with repetition in some areas. Shorter versions of the audit tools similar to the original West Midlands audit tools were preferred as those tools enabled all high risk areas of practice to be reviewed in one go.*(IPS, 2008, pp. 3)

A repeated issue in the report (pp. 3;pp. 5) is that of the use of alternative audits, either in conjunction or as alternatives to the ICNA, due to perceived weaknesses in the current tool. These included the tool being too long, with over half the respondents (59%) saying they would like to see shortened tools developed, and the database needing simplification. The authors (IPS) maintained that future work must therefore be done on developing additional tools to ensure availability of national tools to allow for continued standardisation, ultimately leading to the launch of the QIT range in 2011.

2.8. Chapter Summary

Chapter 2 has developed the Chain of Infection theme from Chapter 1 to emphasise the importance of hand hygiene as an infection prevention and control strategy within healthcare. However, even with such evidence the chapter has also demonstrated how despite evidence-based guidelines to ensure effective hand hygiene, expected compliance is seldom found. This has generated a need for the development of improvement strategies within this field. Finally the discussion has presented the first of three core themes of the current research, that of hand hygiene measurement, highlighting the challenges faced in ensuring reliable, valid and easily sourced data from which to form intervention benchmarks. Systematic measurement, in the form of auditing as a component of QM, has been seen to have success within the healthcare sector, with auditing tools being developed specifically for the purpose of hand hygiene measurement.

The next chapter addresses the two parallel themes at the heart of this current research, the potential of technology to measure hand hygiene compliance and the role of human behaviour.

Chapter 3

Hand Hygiene: Technologies and Human Behaviour

A review of the literature

Part A: Hand Hygiene Technologies: Structured Literature Reviews

The problem of ensuring timely, accurate measurement of hand hygiene compliance has been established. Even the gold standard method of direct observation has been seen to have well documented, widely acknowledged limitations. These include affecting observed behaviour of healthcare professionals and being a burden to undertake, especially to produce sufficient amounts of data to perform detailed analyses.

Recently there has been a rise in prominence of Electronic Monitoring Systems which claim to be able to perform audit tasks in healthcare settings, delivering hand hygiene compliance data to healthcare professionals and their respective organisations (Boyce, 2011; Thomas, 2010). The purpose of the literature review here was two-fold. Firstly to discover the types of hand hygiene related technologies currently available, so that examples could be used in discussions with healthcare professionals. Secondly to establish their Fit for Purpose (FFP) with regard to the case study site auditing needs. The results of this literature review chapter provided the foundation for Study 2 (Chapter 6).

3.1. Types of Hand Hygiene Technology

3.1.1. Database Searching

An initial literature search into technologies within the field of hand hygiene was carried out between October 2009 and February 2011. Using a multidisciplinary approach this searched nine databases from four disciplines: Medicine, Business Management, Engineering and General Knowledge (Table 3-1)

Table 3-1: Details of databases used from a multidisciplinary background to provide wide search scope

Discipline	**Database**	**Dates Covered**
Medicine	MEDLINE	1966 – Oct 2009
	Cinahl	1982 – Oct 2009
	Embase	1974 – Oct 2009
Business Management	ABI/Inform Global	1971 – Oct 2009
	Emerald	1989 – Oct 2009
	Business Source Premier	1922 – Oct 2009
Engineering	CSA High Technology Research	1960 – Oct 2009
	Ei Engineering Village	1969 – Oct 2009
General Knowledge	ISI Web of Knowledge	1970– Oct 2009

The key words were split into two category strings, one to represent hand hygiene, and one to represent technology (Table 3-2).

Table 3-2: Strings used to generate hand hygiene and technology articles

Hand Hygiene	“hand washing” or “hand wash” or “hand hygiene” or “hand clean” or “hand cleaning”
Technology	"sensor" or "sensors" or "electronic" or "electronics" or "technology" or "technologies" or "automatic" or "automation" or "robot" or "robotics" or "ultraviolet" or "light"

These strings, with the words separated by the operator *OR* were then connected by the operator *AND* and were used to perform literature searches in the aforementioned databases.

3.1.2. Article Selection Criteria

Due to the multidisciplinary background of the topic being researched, and the high likelihood that articles returned may be of a non-empirical format (e.g. informative articles from technology companies) a strict Cochrane inclusion criteria (Cochrane EPOC Review Group, 2002) was not followed. Thus research which was of non-rigorous design and non-empirical articles were accepted into the review, as the aim of the literature review was to explore the available documentation, rather than critically assess it. There were, however, some limits applied to articles returned by the database searches, outlined in Table 3-3.

Table 3-3: Limits applied to articles returned from database searches

Considerations for *Type of Technology* Literature Review articles
Due to the skill set of the researcher and time available for analysis, only articles written in English were included.
The key behaviour being targeted by the review was hand hygiene, however articles describing this in any recognisable form were accepted e.g. hand washing, hand sanitisation, and cleansing of hands. It was not the direct term *hand hygiene* that was the target object, but the behaviour to which it refers.
Technology can cover a wide range of potential solutions, applications and devices depending on the field and interpretation of the user or setting. For this review only technology with an electrical component was deemed relevant, due to the co-existence of the term *electronic monitoring* in the context of hand hygiene (Boyce, 2011). Therefore returned articles which discussed hand hygiene in relation to any other technology (e.g. use of Plasma, UV light and hydrogen peroxide decontamination) were discarded.

3.1.3. Search Methodology

Articles were included that discussed any type of participants, be they adults, children, from the healthcare profession or from the general public. No restrictions were placed, indeed articles where no participants were mentioned were also included e.g. articles purely about technology or patents. Whilst the research here is focused on technology for the healthcare setting, at the initial stage no restriction was placed on the inclusion of articles discussing alternative settings e.g. food sector. Similarly although the current research is based within an NHS setting, no restriction was placed on the geographical location cited within articles. These decisions were made in recognition of the aim of the literature review, to explore documentation on hand hygiene technology, with no pre-conception as to whom the intended audience or user may be.

Where returned articles discussed empirical findings relating to technologies, explicit notes were taken. These notes were retained as indicators of the potential quality/usefulness of the specified technology. However, articles that did not cite empirical testing or evidence of quality assurance were not discarded from the review, for reasons discussed earlier.

3.2. Types of Hand Hygiene Technology Results and Discussion

The initial search returned a total of 5,197 articles, reduced to 587 after a relevance review of the title. A detailed analysis of abstracts, and a search for duplicate articles reduced this further, leaving 95 articles for review. The preliminary findings from the search confirmed that technologies had been developed specifically for the healthcare industry. After further analysis those

articles which discussed innovations within the food industry (14 articles), or were otherwise not healthcare related (37) were discarded in favour of retaining only those with a healthcare focus (44).

The resulting 44 articles were published between 1991 and 2010, with only two websites having no date of origin available. A clear increase was apparent with regard to the number of articles published on this topic in recent years: more than 2/3 of these articles (68%) were published from 2006 onwards.

Further articles were discarded at this stage based on availability of full text (3), due to the article having an alternative focus (e.g. behavioural change) (6), being literature reviews (5), or not featuring electronic technology (6). Decisions made during the literature search can be seen visually in Figure 3-1.

Of the 24 articles retained for final analysis 12 were reports, 11 were empirical studies, and one was a patent. Both quantitative and qualitative studies were reported including controlled trials, before and after studies, cross-over studies and observational studies.

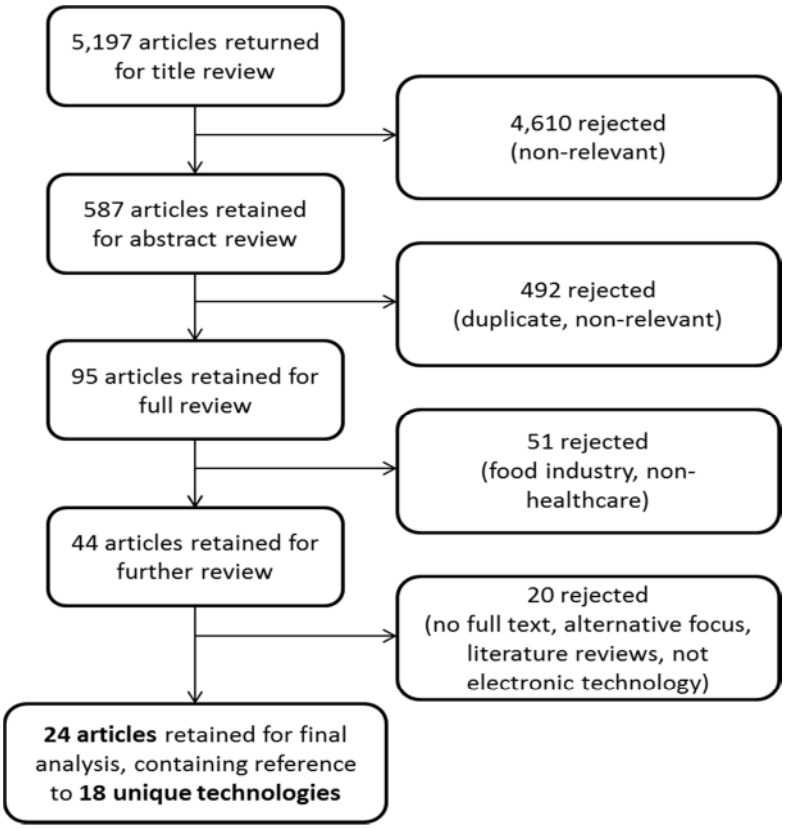


Figure 3-1: Inclusion and exclusion decisions made during literature review search to identify types of hand hygiene technologies

3.2.1. Uses for Current Research: Identifying Unique Technologies

The literature review had a specific objective: to identify the scope of application of technology within the context of hand hygiene in preparation for interviews underpinning Study 2. Each of the remaining 24 articles (Figure 3-1) were categorised to provide a reference resource for “Type of Technology", based on the main characteristics of the system being discussed. As many of the articles were industry reports (12) all were re-screened to identify how many unique technologies could be identified.

18 individual technologies were identified from the 24 articles, either by existing trade/brand name, parent company name, or from a description given from the

article author/s. Where no distinctive features could be distinguished from the article a generic category was assigned e.g. Electronic Counters in Dispensers.

Three articles discussed the same technology being developed at an institute in Canada (Anon, 2010; Birch, 2008: Boscart et al., 2008), five articles discussed uses of electronic counters in ABHR or soap dispensers to monitor hand hygiene levels in various settings (Marra et al., 2010; Boyce et al., 2009; Marra et al., 2008; Kinsella et al., 2007; Larson et al., 2005), whilst the remaining technologies were all featured in one article each.

3.2.2. Categorisations of Technologies

The returned articles showed a wide spread of technologies, with little repeat reporting of innovations (barring the use of electronic counters in dispensers). This indicated a lack of available literature within the rapidly developing area of hand hygiene technology. This is despite clear time and financial effort being invested within the field, reflected in the presence of nine fully developed, identifiable, market available technologies within the returned search articles. The lack of such literature raises concerns as to the empirical rigour underpinning the design and development of technologies within the domain of hand hygiene, leading to the question “are they Fit for Purpose?” discussed further in the next section (see 3.3.).

Of the 18 identifiable technologies (nine of which were classified as *market available*, being commercial products) the majority (13/18) could record rates of hand hygiene, either individually or collectively via communal facilities e.g. ABHR dispensers. Capabilities were present to record hand hygiene at room entry

and exit, or at a more advanced level, linked to a specified Patient zone. Of those unable to monitor hand hygiene rates two were auditing tools, two were automated/heated sink innovations, the other was an electronic prompting sign.

The 18 technologies were also categorised into four main "Types of Technology" (Table 3-4), based upon their overall design. These categories were: a badge monitoring individual hand hygiene behaviour, a dispenser monitoring individual product usage, a surveillance system able to monitor both individual behaviour and product usage within a specified area, and other.

Table 3-4: The 18 identifiable technologies split into four main categories from which to draw examples for Study 2 participants

Type of Technology	**Overview**	**No. of Examples**
Healthcare Professional Badge system	Worn data collection devices. Tracking ability to measure individual compliance	3
Healthcare Professional Dispenser system	Worn data collection devices issuing decontamination aid. Ability to measure individual compliance	2
Healthcare Professional Surveillance System	Complex systems able to monitor and measure hand hygiene within specified area	5
Other	Heated Wash Basin; Automated Sinks; Sensing Beams (Room Entry/Exit; Sign triggering); Counters in Pumps; Data Entry/Collection system	8

Removal of innovations unable to track individual behaviour (e.g. collecting collated data, such as all uses of a shared product dispenser) reduced the 13 monitoring technologies to ten, and eliminated the other category.

Three examples from the ten technologies with individual based monitoring capabilities, one from each of the three remaining "Type of Technology" categories (Table 3-4), were extracted (Appendix 2a). These formed the basis for discussion for Study 2, investigating the views of healthcare professionals on the potential for technologies for the monitoring, measurement and feedback of hand hygiene performance within an NHS acute setting.

3.2.3. Observations of Technology limitations regarding WHO 5 Moments

A descriptive review of the 18 unique technologies returned by the literature review designed to identify the types of technology currently available within the hand hygiene context appeared to reveal none able to replace manual auditing at the WHO 5 Moments. None were able to independently monitor, measure or provide feedback at each of the WHO 5 Moments. The closest technology type, designed at an institution in Canada (Boscart et al., 2008), was able to detect activities related to three out of the 5 WHO Moments (identified as Moments 1, 4 and 5[10]). However the majority of the technologies appeared unable to detect any. Whilst 12 were able to detect activity at door entry/exit the level of overlap this may have with Moments 1 and 4 (*Before Touching a Patient*, *After Touching a Patient*) is impossible to ascertain, as the chance of contamination between entering a room and reaching a Patient, and contaminating the environment/other individuals after leaving a Patient and before exiting a room, remains. Crucial to note when considering the 5 Moments is the intention of the healthcare professional when performing the hand hygiene. For example, Moment 1 relates not to entering a specific area, but to the intention to make contact with a Patient.

[10] Here the Canadian system used a 4 Moments design, with Moment 4 representing both Moment 4 and 5 of the WHO "My 5 Moments for hand hygiene" system.

Thus expecting hand hygiene merely due to entering a specified zone is not wholly within keeping with the approach.

As the literature review began in 2009, the year the WHO launched the 5 Moments globally (Sax et al., 2009), it is not surprising that such guidelines were not part of the development of the technologies identified. It is highly likely that the majority, if not all, of the innovations featured were developed prior to the 5 Moments reaching global audiences. However, as auditing based on the WHO 5 Moments has been widely and successfully implemented (Allegranzi et al., 2013; Sax et al., 2012), and a main aim of hand hygiene technologies is to reduce the burden of manual auditing (time saving potential, Boyce, 2011; reducing manual efforts, Wright 2008) the potential for a synergy between the two requires investigating. This concept, of whether hand hygiene technologies can be considered 'Fit For Purpose' with regard to handling the demands of hand hygiene auditing is considered in depth in the next section.

3.3. Establishing Fit for Purpose

The WHO 5 Moments have been established as a successful, user-centred and evidence based approach to considering when to practice hand hygiene within a Patient care scenario (Allegranzi et al., 2013; Sax et al., 2012). Hand hygiene is recommended at five specific moments to prevent the cross-transmission of contamination, and thus reduce the risk of HCAI (Figure 3-2).

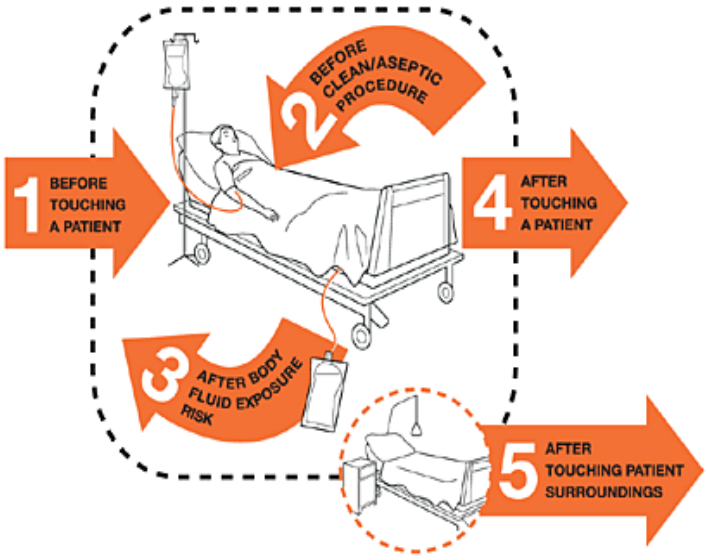


Figure 3-2: WHO 5 Moments for hand hygiene, based on key points of risk for cross-transmission

A second literature review was performed with a more specific search criteria based on the output of the first literature review. This had recovered no technologies specifically designed around the WHO 5 Moments.

However, as the original search criteria did not explicitly include the term *My 5 Moments* a conclusion as to their non-existence could not conclusively be made. It may have been a flaw in the search that led to no articles being returned demonstrating technologies able to fulfil the goal of monitoring, measuring and providing feedback at these key Moments. Thus, the second literature review aimed to identify the existence of any current technologies able to monitor, measure and provide feedback at each of the WHO 5 Moments, as would arguably be required to provide an effective, reliable and suitable alternative to direct observation.

3.3.1. Database Searches

Six databases covering a multi-disciplinary scope (Medicine, Ergonomics, Engineering, and General Knowledge) were used along with expert consultation and internet searches, between November 2011 and November 2012.Three word sets were used to generate articles (Table 3-5). Hand hygiene literature shows varied nomenclature for the practice of hand decontamination, thus key texts (WHO 2009; MeSH terms) were reviewed to provide search terms for Set 1.

Table 3-5: Word sets used for article generation in FFP literature review

Set 1 Hand Hygiene:	"hand hygiene" or "handwashing" or "handrubbing" or "hand rubbing" or "hand antisepsis" or "hand decontamination" or "hand degerming" or "hand cleansing" or "hand disinfection"
Set 2 Technology:	"electronic technology" or "hand hygiene technology"
Set 3 WHO 5 Moments:	"My 5 Moments of Hand Hygiene" or "WHO 5 Moments"

Words within sets were separated using the operator *OR*, sets were conjoined using the operator *AND*. Databases were date limited to 2009 (WHO 5 Moments published) to Current Date. Default language was set to English. The search field, dependent on database (Table 3-6), was selected to maximise article returns.

3.3.2. Search Methodology

Articles mentioning electronic technology being applied to a healthcare setting to monitor, measure or provide feedback on hand hygiene were selected for analysis. Numbers of articles matching the criteria for each set were recorded, as were the number of articles returned through interactions between sets using the *AND* operator (Table 3-6).

Table 3-6: 193 articles returned from literature review, split by Sets

	Set 1 Hand Hygiene	**Set 2 Technology**	**Set 3 WHO 5 Moments**	**Articles Returned**		
				Sets Combined		
	hand hygiene or handwashing or handrubbing or hand rubbing or hand antisepsis or hand decontamination or hand degerming or hand cleansing or hand disinfection	electronic technology or hand hygiene technology	My 5 Moments of Hand Hygiene or WHO 5 Moments	Set 1 "AND" Set 2	Set 2 "AND" Set 3	Set 1 "AND" Set 2 "AND" Set 3
Medline Search Field: Keyword	1293	19	1	0	0	0
PubMed Search Field: All Fields	1841	14474	58	47	0	0
Ergonomics Abstracts Online Search Field: Tx All Text	69	914	10	0	2	0
Scopus Search Field: Advanced Search	1889	1437	106	33	7	2
Engineering Village Search Field: Keyword Database: All	340	58615	24	23	0	0
Web of Knowledge Search Field: Topic	4322	12055	231	79	0	0
				182	9	2
				Returned Articles = 193		

A finite list of technologies was identified from the returned articles (Table 3-6), which were assessed for Fit for Purpose using a bespoke matrix (Figure 3-3).

Fit-For- Purpose Capability	Award score if…
Monitoring	Technologies discuss ability to monitor healthcare professional hand hygiene – *can the technology detect whether hand hygiene is being performed?*
Measurement	Technologies discuss ability to measure healthcare professional hand hygiene – *can the technology provide information about hand hygiene performed?*
Feedback	Technologies can provide feedback about healthcare professional hand hygiene – *either Real-Time (such as beeping, flashing, vibrating prompts) and/or through data reporting.*
WHO 5 Moments	All of the above should be around the 5 Moments: 1. Before Touching a Patient 2. Before Clean/Aseptic Procedure 3. After Body Fluid exposure risk 4. After Touching a Patient 5. After Touching Patient surroundings

Figure 3-3: Fit for Purpose (FFP) Matrix

The FFP matrix was developed to allow each identified technology to be rated on their ability to monitor, measure, and provide feedback around each of the WHO 5 Moments. The matrix allowed a scorecard approach to be used for analysis, with each technology scoring a '1' per capability it could achieve. The maximum score would thus be '8'; the minimum score would be '0'.

The process of FFP assessment was conducted independently by two reviewers (the researcher and a colleague), with discrepancies recorded then resolved through discussion and joint review. For completeness both reviewers performed a further search using references, expert consultation and a Google Search of *hand hygiene technology* in January 2013, with the matrix scorecard being applied jointly.

3.3.3. Fit for Purpose Results and Discussion

The initial review from the six databases returned 193 articles, of which 178 were rejected as duplicates or as not relevant (e.g. technology not being the subject of the paper, hand hygiene not being the subject of the paper, being Systematic Reviews within the area). 15 were retained for full review. Both reviewers examined the 15 articles for relevance. Five were rejected due to relevance (for being review articles or the technology not being the subject of the paper). Therefore a total of ten articles were retained for full analysis containing reference to seven unique technologies. Further searching in January 2013 identified 12 additional technologies which were also assessed using the FFP matrix scorecard approach (Figure 3-3). This resulted in 19 unique technologies being assessed for FFP and available for discussion. The process of the review is outlined in Figure 3-4.

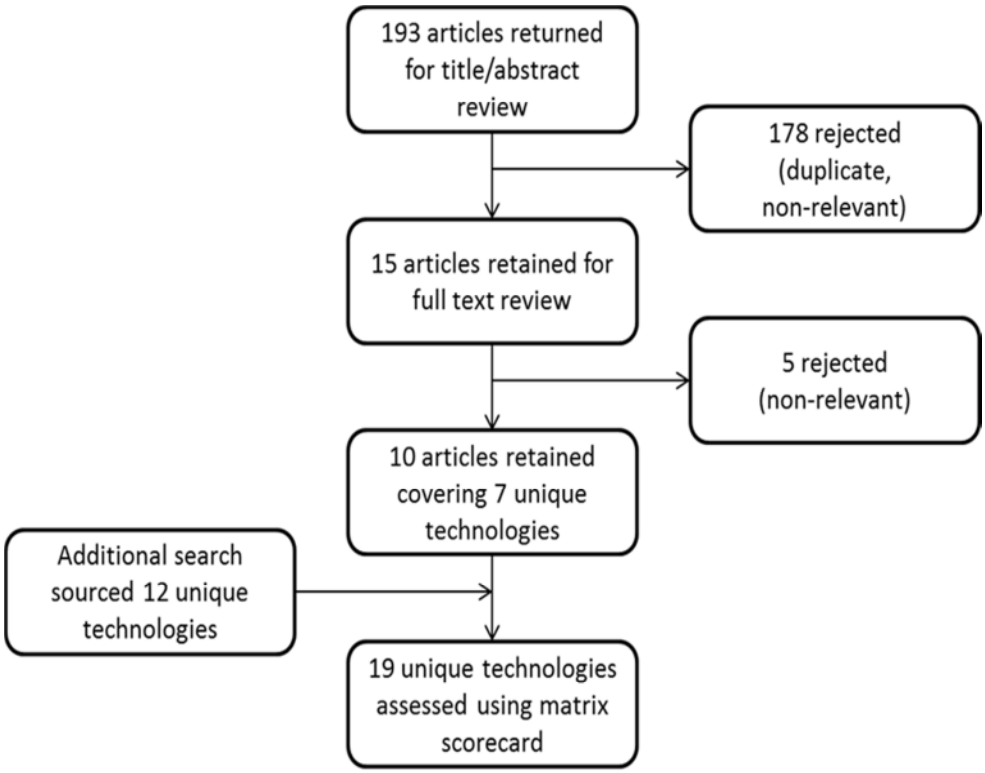


Figure 3-4: Flow-diagram of inclusion and exclusion decisions during the review process resulting in 19 unique technologies being assessed by the Fit For Purpose matrix

3.3.4. Uses for Current Research: Assigning Fit for Purpose

As with the previous literature review the research results highlighted diversity in the range of technologies available, with innovations employing (for example) radio frequency identification (RFID), infrared detection, wireless networks and video monitoring. Of note, details regarding technical specification, system capabilities and testing to date was limited, especially for the 12 technologies found from non-database sources. Of the 19 technologies found (see Table A-3, Appendix 2b), none were deemed fully Fit for Purpose in their ability to monitor, measure and provide feedback at the WHO 5 Moments. Moments 2 and 3 proved most problematic for technological solution (Table 3-7).

Table 3-7: Number of technologies possessing each FFP criterion

FFP Variable	Number of Technologies possessing criterion
Monitor	19
Measure	19
Feedback	19
Moment 1	15
Moment 2	0
Moment 3	0
Moment 4	14
Moment 5	3*

* See 3.3.4 a) for further discussion.

a) Monitoring at Moment 5

Fourteen out of the nineteen technologies were able to provide monitoring, measurement and feedback at both Moments 1 and 4, albeit slightly more based at a room entry/exit level (8 technologies), rather than specifically based around the ideal Patient Zone concept (6 technologies). Limitations regarding this have previously been noted (see 3.2.3.).

Definition of detection of Moment 5 was not necessarily clear. No technologies specifically made reference to being able to measure or detect contact with the Patient environment. However three technologies had the capabilities to specifically detect healthcare professional activities within the Patient Zone. Therefore it could be inferred that potential contact with the Patient environment could be deduced from hand hygiene data collected via such mechanisms. Based on the evidence that hands can become contaminated through activities involving routine contact with objects within the Patient environment (Tenorio et al., 2001;

2.4.3.) a recommendation for technology developers may be that this is an area which would benefit from equal attention as Moments 1 and 4. To add weight to this notion, the current research has a specific focus on areas of potential weakness, both perceived and actual, in terms of performing and measuring hand hygiene. These findings are to be discussed in regard to the current capabilities of hand hygiene technologies, and recommendations for future developments.

b) Monitoring at Moments 2 and 3

The finding that no current technologies are able to monitor, measure or provide feedback at Moments 2 and 3 supports the finding reported in a review by Boyce (2011), and may not be surprising considering the specific requirements of these Moments.

Moment 2 requires hand hygiene to be performed *Before Clean/Aseptic Procedure*. Therefore any technology designed to aid hand hygiene must be able to predict such a clinical activity is about to occur in order to capture the healthcare professionals hand hygiene behaviour accurately, and/or deliver a prompt to action if necessary. Such behaviour predicting technologies, a potential outcome of future work within the emerging field of cognitive neuroscience, are certainly still a long way from the high-demand, high-work intensity environment of the busy clinical setting, if ever feasible. Furthermore, should such innovations occur the question of whether healthcare professionals would engage with technologies able to "read their minds" to deem what actions they may take next is doubtful, considering existing hesitancy when faced with the idea of hand hygiene technologies as a concept (Ellingson et al., 2011).

Moment 3 requires hand hygiene to be performed *After Body Fluid exposure risk*. The challenge for any technology designed to aid healthcare professionals to improve compliance at this Moment is the detection of such a risk having occurred. Various clinical Patient care duties may characterise Moment 3 including wound dressing, drawing up and manipulating fluid samples and handling waste (e.g. bandages). Crucially these do not necessarily have to involve the visible soiling of hands (Sax et al., 2007). Therefore technologies able to detect the physical presence of bodily fluids (e.g. fluid sensors) would not be sufficient. It is the *risk* of hand contamination that is the driver behind Moment 3, the potential contamination of the hand surface, rather than only being applied to situations where actual physical soiling has occurred. Often contamination may be at a microbial, invisible level.

c) Monitoring at Moments 1, 4 and 5

Of the 19 technologies, three were able to detect Moments 1, 4 and 5. Monitoring, measurement *and* feedback was possible by all three technologies at all three Moments. This offers the potential for healthcare professionals to both collect data about performance, essential to measure the impact of interventions, and have the opportunity for real-time reminders to be given for individuals to perform required hand hygiene.

Feedback has been shown to improve hand hygiene performance both with technology (video surveillance; Armellino et al., 2012; Ghosh et al., 2012) electronic measurement tools (RFID system Sahud et al., 2012; ABHR sensing badges; Edmond et al., 2010) and with multi-modal interventions (Pessoa-Silva et al., 2007; Pittet et al., 2000).

The advantage of systems with the ability to provide individual data about specific Moments of Patient care (Moments 1, 4 and 5) is the opportunity to identify areas of strengths/weakness which are linked to pre-existing themes of training and awareness. The WHO 5 Moments are globally recognised evidence based standards for hand hygiene and have a vast resource to allow organisations to deploy training and education. Therefore systems which can measure performance based upon the same recognisable standards can provide meaningful feedback to all levels of staff, allowing for a beneficial continuous improvement cycle to occur. Targeted interventions can be designed to develop interventions at specific Moments with lower hand hygiene compliance.

3.3.5. Potential for Hand Hygiene Technologies

Whilst no technologies were found that proved Fit for Purpose for all 5 WHO Moments, this may not infer that electronic monitoring has no place in the clinical setting. With the acknowledged limitations of the observational method, and the clear advantage of accurate, relevant data for healthcare professionals to improve their hand hygiene, technology could be seen as an ideal aid to measurement, rather than a one stop solution.

An advantage of technologies using infra-red and radio-frequency is their ability to monitor *behind the curtain*, an often cited problem of the direct observer (see Boyce, 2011). In these scenarios many opportunities to observe healthcare professional behaviour are missed or interrupted by Patient care taking place out of sight of the observer, often literally behind the curtain, within the Patient Zone (van de Mortel and Murgo, 2006). This is often for privacy reasons (the observer being unable to follow), however sensory technology, once passed by hospital

regulators, is not restrained by such barriers, therefore data could continue to be collected undisturbed. Further, it has been suggested that technology may significantly reduce observation effects (Cheng et al., 2011).When comparing electronic and manual surveillance Cheng et al. (2011) demonstrated measured compliance levels 2.8 times higher for manual observation sessions than for electronic surveillance only sessions. Hand hygiene technologies may therefore provide a source of less skewed data from which to plan future interventions.

Crucially, though, the Fit for Purpose literature review uncovered clear limitations in current abilities to detect all the WHO 5 Moments. Whilst an objective of the current research is to ascertain the views of healthcare professionals as to the significance of such a finding to their perceptions regarding hand hygiene technologies, these limitations remain. Interestingly, however, behavioural theory used to explore hand hygiene motivations may provide an alternate area for exploration in terms of how to "bridge" such limitations going forwards.

Part B: Hand Hygiene and Behaviour

The topic of hand hygiene and behaviour has been alluded to previously. Here the specific theory of relevance to the case study research is to be examined in detail.

Curtis and Biran (2001) offered insight into hand hygiene behaviour, based on their cross-cultural work involving Africa, Europe and India. Despite notable cultural differences in socially normal behaviours relating to hand hygiene the authors identified a consistent trend: the avoidance of *disgust* was a key motivator for hygienic behaviours.

That disgust would be a unifying principle across cultures is not surprising considering the authors review of disgust as a basic human facet, citing Darwin's inclusion of disgust as one of six basic emotions. Explanations of disgust may be both psychological and microbiological, yet Curtis and Biran propose an inherent, evolutionary origin, designed to protect the individual from coming to harm.

However, hand hygiene also occurs in situations where disgust is not present, and indeed this is often imperative for effective hand hygiene in healthcare settings. Therefore further theoretical models have sought to explore in more depth the motivations underpinning hand hygiene.

3.4. Hand Hygiene and Behaviour Models

From the myriad of theoretical models that have been explored with an application for hand hygiene Nicol et al. (2009) report the predominant model used has been the Theory of Planned Behaviour (TPB, Ajzen, 1991). The TPB is designed to explain intended behaviour, using constructs of Attitudes, Social Norms and Perceived Behavioural Control (Figure 3-5). Behaviour is seen to be determined by the output of the intention, mediated by the level of control perceived by the individual at the point of decision making.

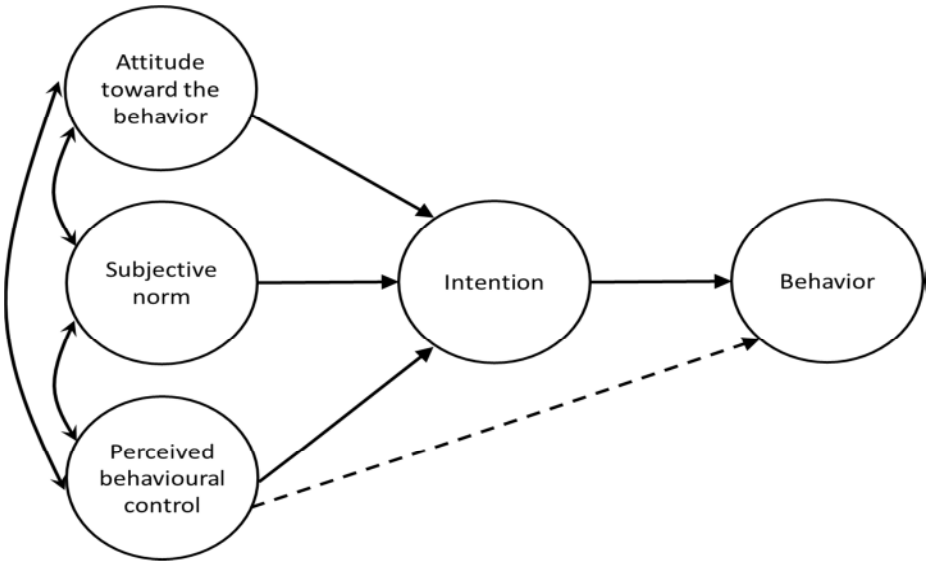


Figure 3-5: Theory of Planned Behaviour (TPB) *(Reproduced from Ajzen, 1991, pp. 182)*

An early application of the TPB to hand hygiene was carried out by Jenner et al. (2002). They used a survey of healthcare professionals to create and validate a TPB model specifically for hand hygiene, incorporating additional constructs which may affect both intention and behaviour (e.g. barriers, personal responsibility). Attitudes were found to predict intentions, though the authors note that only 1/3 of participants said *they always liked/expected/intended/wanted to wash their hands before and after contact with each patient* (pp. 321). Personal responsibility, an additional construct of Jenner et al. (2002) was also found to significantly predict intention. Neither subjective norms nor perceived behavioural control, nor the additional construct of barriers, were found to significantly predict behavioural intention.

In terms of actual behaviour, intention and perceived behavioural control were found to be significant predictors, the latter being mediated by two of the four included specific barriers (time; number/availability of sinks). The survey findings led to the formation of an adapted TPB model for hand hygiene (Figure 3-6).

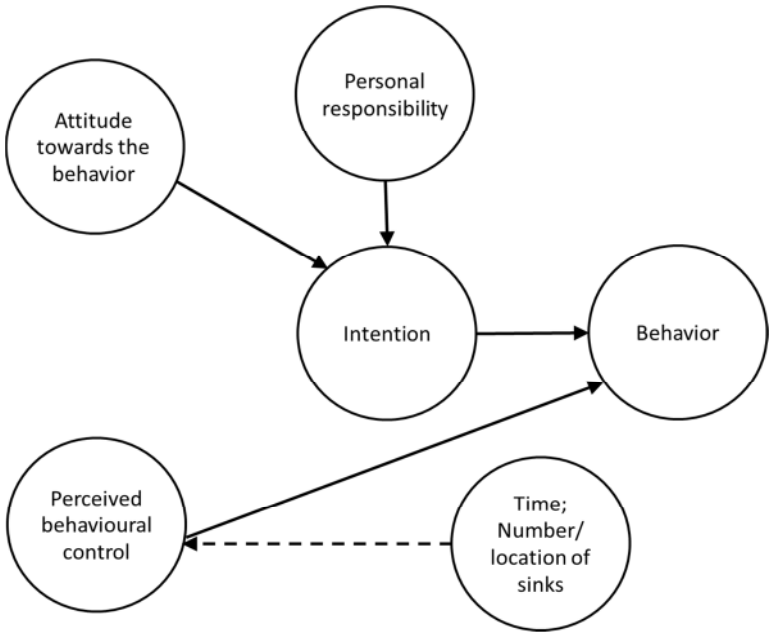


Figure 3-6: TPB Model for hand hygiene from Jenner et al. (2002)

Nicol et al. (2009) provides a further adaptation of the TPB for hand hygiene, including additional elements which may influence the main constructs (attitudes, social norms and perceived behavioural control). Amongst these additional elements was the influence of past experience, which was seen to form attitudes. Both Nicol et al. (2009) and Jenner et al. (2002) use their work and subsequent models to support the view that hand hygiene education requires an experiential element, based on the evidence for the influence of experience on constructs to behavioural intention, ultimately an influence on behaviour itself.

Whilst the TPB is useful in providing a conceptual framework in understanding hand hygiene behaviour, no version or study employing this approach has been able to demonstrate consistent results translating reported intention into actual behaviour. The focus of the current research investigates a behavioural theory which seeks to no longer consider hand hygiene as a singular homogenous behaviour, rather considering it as consisting of two elements, which may have separate, distinct constructs.

3.5. Inherent and Elective Hand Hygiene

The emergence of Inherent and Elective hand hygiene can be traced back to the work of Whitby et al. (2006).

They used focus groups involving nurses, mothers and children aged 9-10 to elicit views regarding hand hygiene, both in daily life (community setting) and within a healthcare setting. Children were heavily influenced by what they were taught at home (here explored through mother's views). Such training was found to commence from the time of weaning and/or toilet training, with continual reinforcement. The child participants were able to display knowledge of the need to perform hand hygiene to rid hands of contamination, understanding that *although water can get rid of surface dirt on hands, it is necessary to use soap to ensure that "germs" are killed* (pp. 485). The adult participants, mothers and nurses, attributed hand hygiene to a habitual process, rather than believing that each incident stemmed from a conscious association with specific actions. They did note, however, that both physical and psychological drivers may cause them to perform decontamination on occasion.

Using focus groups investigating hand hygiene behaviour when facing specific scenarios (e.g. such as playing on a swing, using a public or home bathroom) Whitby et al. (2006) found participants considered context to play a key role in their decisions:

> *The need to wash hands after using the toilet was even more important if the toilet was for public use, because children perceived a public toilet as having the potential to harbor "more germs" than their toilet at home. This attitude was unanimously supported by both mothers and nurses, who held public toilets in very poor regard because they are "grotty" and a "haven for germs"*

(pp. 486)

In a healthcare setting the nurse participants considered that hand hygiene was not always essential for Patient contact, with “non-intimate” tasks less likely to lead to a believed need for hand hygiene. For example, taking the blood pressure of a Patient, deemed “non-intimate touching of a Patient”, or the use of “inanimate Patient objects” such as clean linen/Patient clothing, were less likely to motivate hand hygiene when compared to tasks requiring prolonged physical contact.

Nurses reported that when performing their hand hygiene “requirement assessment” a key driver was the concept of *dirtiness*. A task perceived as dirty, either physically *or* emotionally, would lead them to perform hand hygiene. This would occur in spite of other constraints e.g. time, multiple job pressures. When under time constraints nurses admitted the necessity of hand hygiene was assessed, thus opportunities not eliciting the category of *dirty*, such as interactions with clean Patient linen, would be likely to be missed. This requirement assessment process was labelled a “Hierarchy of Risk” (Whitby et al., 2006).

Following feedback regarding motivators and attitudes towards hand hygiene from both focus group and questionnaire analysis Whitby et al. (2006) surmised that two hand washing practices could be identified: Inherent and Elective.

a) Inherent Hand Hygiene[11] Behaviour

Whitby et al. describe hand hygiene behaviour occurring when hands are physically dirty, they feel sticky, or after instances when hands have been somewhere considered *emotionally dirty*.

Emotionally dirty: This concept describes instances involving Patient areas such as the groin, axillae or genitals. Such activity may not leave the hands physically soiled, but can still evoke a strong desire to perform hand hygiene.

b) Elective Hand Hygiene Behaviour

Here activity requiring hand hygiene does not instinctively drive the behaviour, instead it may consist of actions such as non-invasive touching of a Patient (e.g. taking a pulse), or interactions with equipment or belongings within their surroundings (e.g. curtains, bedside table).

This hand hygiene may be seen by the individual as something that *could* be avoided. This is not to be implied that it *should* be avoided, as contamination of the hand surfaces may still occur through such activities (see 2.3, 2.4.). The implication is that the behaviour must be decided upon, rather than being an automatic reaction. Thus within healthcare there may be hand hygiene requirements (*should*) that individuals may not perform (*could*) after deciding hand hygiene lacks priority compared to other tasks.

[11] Whitby et al. (2006) use the term Inherent handwashing throughout their literature. However, as previously explained (see Glossary) – the predominant descriptive word for hand cleansing in this thesis is hand hygiene, thus to avoid confusion, unless a direct citation the terms Inherent and Elective hand hygiene are to be used going forwards.

3.6. Internal "Hierarchy of Risk" decision making for Hand Hygiene

O'Boyle et al. (2001) found that observed hand hygiene adherence fell when activity in a nursing unit increased. Time pressure and workload have been found to be independent predictors of low hand hygiene compliance (Hugonnet et al., 2002; Pittet et al., 1999). In terms of the work of Whitby et al. (2006) this may suggest that the observed individuals (critical and post-critical care nurses) accessed an internal "Hierarchy of Risk" during this pressured time, making hand hygiene decisions based on *could* rather than *should*.

This appears further supported by the finding of O'Boyle et al. (2001), which showed a higher rate of self-reported hand hygiene than observed hand hygiene (average self-reported rate 82%, average mean observed rate 70%). Participants were asked to provide feedback regarding the percentage of times they performed hand hygiene at key points within the healthcare setting (Table 3-8).

Table 3-8: Activities used by O'Boyle et al. to compare self-reported and observed hand hygiene performance

Activity
Before care
When care was interrupted
Between Patients
Before performing an invasive procedure
After contact with contaminated material and before beginning a clean procedure on the same Patient
After removal of gloves
After direct contact with body fluids
Before touching own mouth, nose, eyes, and face with contaminated hands

The same participants were also observed for a period of two hours, or until ten hand hygiene opportunities had occurred. Hand hygiene opportunities were recorded using the Handwashing Observation Instrument (HOI; Larson et al., 1997) (Table 3-9).

Table 3-9: Hand hygiene opportunities recorded by O'Boyle et al. (2001) using HOI (Larson et al., 1997)

Hand Hygiene Opportunities
Before beginning care and/or resuming care
After completion of care
Before invasive procedures
Moving from dirty to clean procedures
After removing gloves
After contact with body substances
Before the nurse had contact with his/her mouth, eyes, nose, and face (with contaminated hands)

They found participants were over-reporting their hand hygiene behaviour. The self-reported hand hygiene figure was higher than the actual observed hand hygiene figure. This implies the individuals were aware of when they *should* be carrying out required hand hygiene behaviour, but at some point were making a *could* decision not to.

Further support for the hypothesis comes from the additional theme in O'Boyle et al.'s (2001) work, in which the TPB model was applied to investigate the underlying behavioural motivations of nurse's hand hygiene behaviours. Using the Handwashing Assessment Inventory (HAI) (O'Boyle et al., 2001b) motivational themes for each participant were assessed.

The results found that motivational themes were positively associated with participant intention to perform hand hygiene, and also their self-reported levels of hand hygiene. However, the HAI results were not associated with the actual observed hand hygiene behaviour. It was the contextual addition of how busy the nursing unit was that was associated with the observed level of hand hygiene. This further suggests that whilst the staff were able to form behavioural intentions regarding hand hygiene (*should*) behaviour, they then performed different behaviour (*could*) in the face of difficult contextual circumstances.

What is unknown from O'Boyle et al.'s study and subsequent model is how the "Hierarchy of Risk" process would have influenced the potential decisions made by the staff between the formation of their intentions and the performance of their actions within the contextual environment. It is the moving from the *should* to the *could*, where understanding the Inherent and Elective aspect may be of key importance. The current work may offer an insight into this transition. By identifying whether certain activities are more likely to result in hand hygiene than others it may be possible to identify activities more liable to be associated with low hand hygiene due to problems successfully translating from *should* to *could* using the internal "Hierarchy of Risk". This would be especially useful when healthcare professionals are under additional external pressures.

3.7. Decontamination Agent Choice: Driven by Inherent Hand Hygiene

The introduction and increase in prevalence of ABHR, with corresponding literature as to usage, offers an interesting opportunity to explore the phenomenon of Inherent and Elective hand hygiene further. Stone et al. (2007) reported early data from the national NHS (England and Wales) Cleanyourhands Campaign

(CYHC). They found the campaign had significantly increased the use of ABHR (a key aim) without significantly influencing the rate of hand hygiene with soap and water. Indeed, in a separate report (Stone et al., 2007b) the authors strongly defend their work from critique, noting that the increase in ABHR had not been at the expense of soap usage. A further response within this debate came from Whitby and McLaws (2007) who highlighted the similar findings from the original Geneva work of Pittet et al. (2000), where (targeted) ABHR use similarly increased without an increase in hand hygiene with soap and water. Their explanation, based on their 2006 work establishing Inherent and Elective hand hygiene theory, postulated that hand hygiene with ABHR is likely to only reflect moments of decontamination related to Elective activities. Therefore the increased usage in conjunction with specific interventions is unsurprising, as Elective hand hygiene requires specific training, rather than being driven by instinctive behaviour. As both the Geneva model (Pittet et al., 2000) and the CYHC were multimodal in design, containing supportive aspects to model changes in behaviour (e.g. information), the increase in hand hygiene using ABHR is likely to reflect new learning at Elective activities. The stable level of hand hygiene using soap and water arguably reflects Inherent hand hygiene, driven by themes of dirtiness and self-protection. Such incidents of decontamination are unlikely be affected by interventions.

Furthermore, in studies where additional sink provision has not been found to lead to significantly higher levels of hand hygiene (Preston et al., 1981; Vernon et al., 2006; Whitby and McLaws, 2004) the lack of success may be attributed to the underlying Inherent hand hygiene explanation. Whitby and McLaws (2007) argue that Inherent hand hygiene is linked to recourse to decontamination involving

soap and water. As this behaviour is practiced based upon established patterns from childhood and the community, measured values will already be at (close to) maximum levels. The introduction of new sinks are unlikely to significantly increase hand hygiene rates (unless severe restrictions were previously in place) as individuals would already have been following strong drivers of dirtiness and self-protection to perform decontamination when hands were visibly soiled, felt sticky or a sense of emotional dirtiness existed. The introduction of ABHR may lead to observed/measured increases in hand hygiene levels, as discussed, yet these would be at Elective moments, which may previously have been overlooked.

3.8. Current Research

The current research aims to establish how hand hygiene is currently measured at the case study site (Study 1), and then explore the perceptions of healthcare professionals based there with regard to the potential of hand hygiene technologies (Study 2). Using the technology examples and information concerning Fit for Purpose the possible use of such innovations are to be discussed, to allow recommendations for technology developers to emerge.

Based upon behavioural theory (Whitby et al., 2006) the current research aims to explore methods to empirically further Inherent and Elective theory (Study 3). Using both healthcare professional perceptions and an observational study the research investigates whether activities categorised as Inherent may be more likely to result in hand hygiene than those categorised as Elective. The potential for such research to aid technology innovations in light of their known limitations (inability to detect Moments 2 and 3) will be addressed. Using findings from all three studies implications for future systems of measurement, both manual and technological, will then be discussed.

Chapter 4

Methodology

4. Introduction

The current research consisted of three individual studies designed to address a single research question. This chapter details the methodological approach underpinning the research, including rationale for methods chosen to conduct each study. The case study site is also described, with justification as to its suitability.

4.1. Methodological Approach

The research question looked at the importance of both domain knowledge and human behaviour for developing successful audit processes and technologies, within the field of hand hygiene measurement. Due to the scope of the question, the background of the researcher, and the objective of the research to produce recommendations for both healthcare and industrial settings, the research was multidisciplinary in nature, drawing on the approaches and theory of manufacturing, psychology and human factors.

Creswell (1998) suggests that five major traditions of inquiry exist within qualitative research: Biography, Case Study, Ethnography, Grounded Theory, and Phenomenology. The selection of one of these may be influenced by the researchers held paradigm, or world-view, which Creswell goes on to represent with a further five philosophical assumptions: Ontological, Epistemological, Axiological, Rhetorical and Methodological.

The current research agrees with the ontological characteristic outlined by Creswell (1998), whereby reality is understood to be subjective and multiple, due to the numerous perspectives of those involved. Similarly the epistemological approach here followed comparable subjective characteristics, whereby the

researcher attempted to lessen any distance between themselves and the area of research. This included the use of explicit methods (participatory observation) and involvement in activities with participants, including IPCT activities.

Of particular relevance to the current research, Creswell (1998) also proposes that researchers may use social science theories as a method of explaining how the world operates. Here, the emerging theory of domain knowledge was introduced due to the importance it places on the involvement of those within a process, to enable understanding and perception of all aspects of the identified process (Hovenga et al., 2005). Whilst this has parallels to phenomenological research, Creswell identifies the case study as an independent, valid route for inquiry.

4.2. Mixed Methods

Carrying out the three separate studies employed a mixed methods approach, with a predominantly qualitative angle. According to Creswell and Plano Clark (2011) the core function of mixed methods is to use both quantitative and qualitative approaches to better understand a research problem. Indeed, in the current research the use of methods from within the qualitative field (Studies 1 and 2) allowed a deeper understanding of the issue under review, specifically from the view point of those playing a role within the phenomenon. A quantitative investigation (Study 3) allowed a framework to be developed and piloted investigating a specific hypothesis underpinned by existing theory and emergent themes from the preceding two qualitative studies. A case study design was chosen as the appropriate vehicle for the mixed methods approach, as is to be discussed, with Figure 4-1 outlining the structure, showing flow of information, and contributions of each study to the whole.

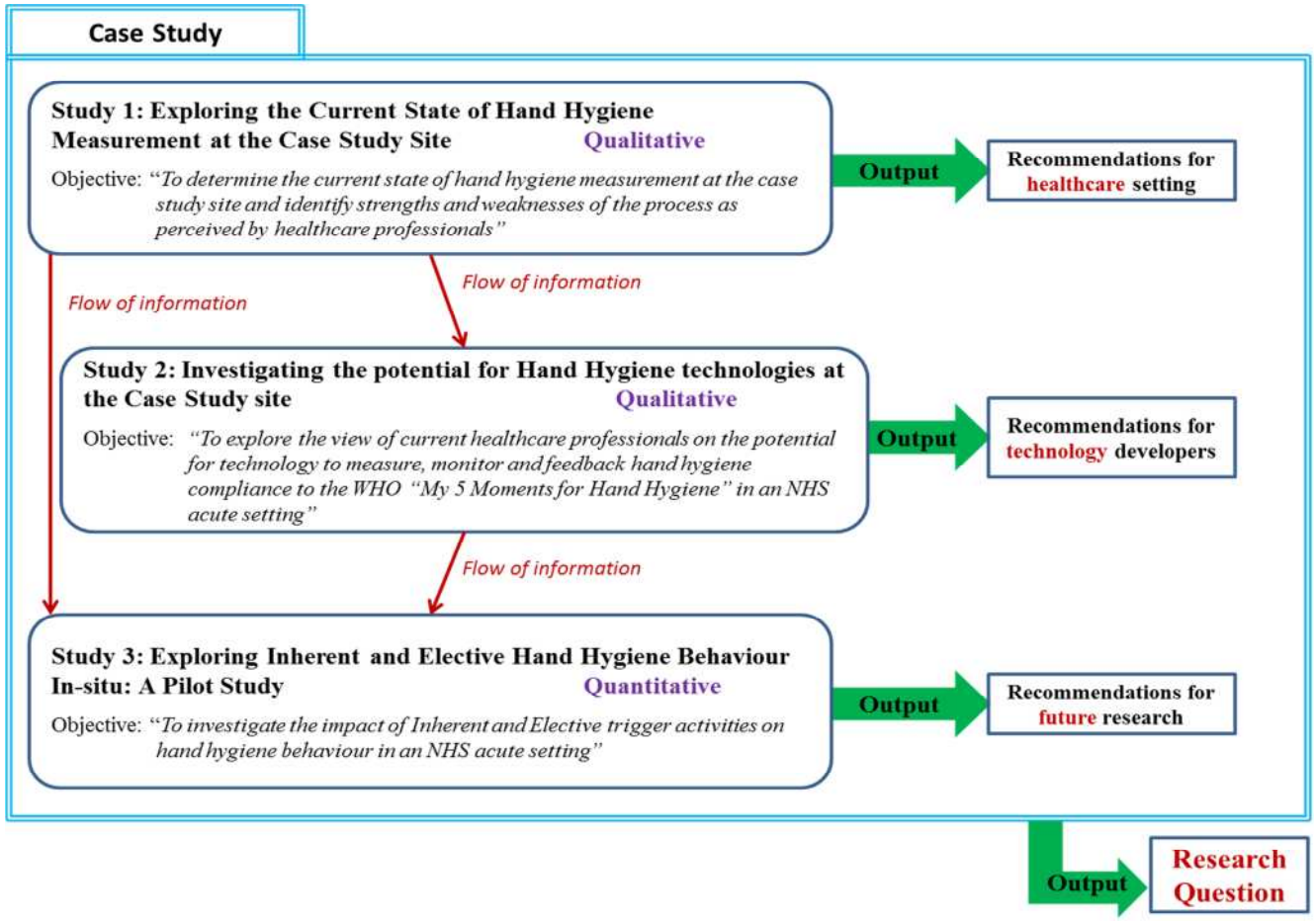

Case Study
Study 1: Exploring the Current State of Hand Hygiene Measurement at the Case Study Site
Qualitative
Objective: "To determine the current state of hand hygiene measurement at the case study site and identify strengths and weaknesses of the process as perceived by healthcare professionals"
Output
Recommendations for healthcare setting
Flow of information
Flow of information
Study 2: Investigating the potential for Hand Hygiene technologies at the Case Study site
Qualitative
Objective: "To explore the view of current healthcare professionals on the potential for technology to measure, monitor and feedback hand hygiene compliance to the WHO "My 5 Moments for Hand Hygiene" in an NHS acute setting"
Output
Recommendations for technology developers
Flow of information
Study 3: Exploring Inherent and Elective Hand Hygiene Behaviour In-situ: A Pilot Study
Quantitative
Objective: "To investigate the impact of Inherent and Elective trigger activities on hand hygiene behaviour in an NHS acute setting"
Output
Recommendations for future research
Output
Research Question

Figure 4-1: The mixed methods case study structure, consisting of three separate studies each contributing independent outputs feeding into the main output for the research question

4.3. Use of Case Study

Hendrick et al. (1993) suggest a categorisation scheme to allow research method selection, using the often cited *what*, *who*, *where*, *how* and *why* series. By considering the category of research question, decisions regarding the appropriate method can then be made. Here, as seen in Table 4-1,decisions regarding the appropriateness of a case study to answer each of the main research question categories were considered.

Table 4-1: Exploring how type of research question can determine appropriateness of case study usage

Research Question Category	Discussion of Appropriateness	Case Study Appropriate?
What	Questions leading to explanatory studies. These could potentially be grounded in any of the five main research methods (Yin, 2009). For example, there would arguably be merit in conducting an explanatory survey, experiment or case study, depending on the suitability of the research at hand.	✓
	Questions relating to how many. Here a narrower selection of research methods is suggested as applicable, such as the survey/archival approach, where quantitative analysis and enumeration of findings would be easier. Yin (2009) further attests that case studies are unlikely to be appropriate to specifically address these type of *what* questions.	**X**

Who, Where	Quantifiable methods such as surveys and the analysis of archive data are more applicable when the research question focuses in on *who* or *where*. This is particularly true when the goal is a description of, for example, prevalence of a particular phenomenon, or to work towards predictive scoping of future outcomes.	**X**
How, Why	When the research is focused on *how* or *why* a phenomenon occurs, Yin (2009) proposes that as these questions are more explanatory in nature, the use of case studies, histories and experiments are appropriate. This lies in the understanding that researching a *how* or *why* question focuses on issues arguably more complex than recording frequencies and incidences, including operational links and organisational frameworks.	✓

As a key objective of the research was to understand the process of hand hygiene measurement within an NHS acute setting, the advantage of a design to allow in-depth analysis of *how* and *why* certain actions occur was particularly apt. Coupled with the fact that the research question was primarily a *what* question, the selection of a case study approach was considered highly suitable.

4.3.1. Case Study as a Methodology

Baxter and Jack (2008) characterise the case study as a methodology, one that employs multiple data sources to explore a given phenomenon. According to Yin (2009) case studies allow insight into holistic and meaningful characteristics of real-life events, and contribute to the knowledge of individual, group and organisational phenomenon. This positioning within the real-world context is further supported by Feagin et al. (1991), who see the case study at the opposite

end of a continuum to the standard laboratory experiment. In a case study the researcher records people engaging in real life activities, whereas in an experiment the setting is an artificial construction of life.

Yin (2009) states that case studies differ from historical analyses by their consideration of contemporary accounts, employing data collection methods involving the direct observation of events, and interviews with the people involved in these events. This differs from the historical analysis, which solely relies on the use of other sources of data, in likeness to case study, including primary documents, secondary documents and cultural/physical artefacts. The similarities shared by these two approaches allow in-depth focus of a phenomenon through wide-ranging sources of data. However the use of real-time observation and interaction with actors involved in the event/s studied are unique tools available to the case study design.

Thus with the present research, similar to the historical analysis method, existing documents were firstly examined as a guide. The ICNA guidelines were examined as the measurement standard that the audit process needed to fulfil, with the monitoring and feedback elements identified as the input and output elements. However, where the research distinguishes itself as a case study is through the application of participatory observation and interviews, to ascertain *how* and *why* this document is used to carry out hand hygiene measurement at the selected NHS acute site. Furthermore, through the use of participatory observation, the researcher was able to walk the process, and gain insight into the challenges and complexities of performing the measurement within the NHS acute setting.

With the case study seen as a methodology appropriate for studying a phenomenon within a real-life setting, using multiple data sources and collection methods, and direct interaction with the actors involved within the phenomenon itself, it was this approach that was determined as suitable for the current research investigating the hand hygiene measurement within an NHS acute setting.

4.3.2. Case Study Design

Yin (2009) acknowledges that case studies can have a mixture of quantitative and qualitative evidence within them, thus fitting well with the mixed methods stance taken by the current research.

Amongst four illustrative definitions of how a case study could be of use Yin argues that the case study can be employed to explain presumed causal links, especially when these links are too complex in nature to be explored by a more quantitative method, such as a survey or standard experiment. Secondly, they can be used in a descriptive manner, to add context to an intervention, recounting the detail in which it occurs. In terms of the current research such advantages allowed the exploration of existing processes (for hand hygiene measurement) and the development of recommendations as to how such processes could be improved moving forwards (Study 1). This included the views of current healthcare professionals on the potential for technology, considering its Fit For Purpose (Study 2). Use of a case study also allowed the development of a framework allowing context to be added to quantitative testing of theory for Study 3 (see Study chapters for details).

Citing work on the development of observational studies, such as Study 3 in the current research, Yin (2009) emphasises the fundamental requirement that case studies require theory development *prior* to beginning research. In the case of the Rosenbaum (2002), the term *multi-phasic* (pp. 6) was used to explain that by exploring the existing knowledge base future observational studies should be designed to explore all possible causal hypothesis for a chosen phenomenon, rather than aiming to over-simplify and thus under-explore an event/theme. Thus, previous work can be used to both inform the direction of study (the propositions), and also be used as a template to compare empirical results of a study. Such considerations guided the design of the case study used here, whereby the final investigation (Study 3) was based both on previous work carried out in this research (Studies 1 and 2), and also existing theory and evidence.

4.3.3. Generalisability

The linking of case study outputs to development of new research is a key tool in defending the method against criticisms of weakness in the domain of generalisability. Here the term generalisable refers to analytic generalisation rather than the statistical generalisation. The latter is arguably more desirable when using a more quantitative approach (Shavelson and Townes, 2002). Analytic generalisation has the goal to generalise findings to theoretical propositions, rather than populations as a whole, the goal of statistical generalisation. The argument is not which approach is best or most desirable simply which is most appropriate to the research being conducted. What is

important for both, after all, is rigour, reliability, validity and clarity of method, allowing repetition.

4.4. Case Study Site

Following the method of Mitchell (1983) the case study site was chosen due to its ability to provide suitable context to explore the theories and phenomena underpinning the current research. These were namely processes of hand hygiene measurement, perceptions of healthcare professionals regarding hand hygiene technologies, and observations of hand hygiene behaviour in an NHS clinical setting.

University Hospitals Coventry and Warwickshire (UHCW) is a large NHS acute Trust, comprising two hospital sites: University Hospital, Coventry, and Hospital of St Cross, Rugby. Both sites were used as locations for the current research. In 2011/2012 the Trust employed approximately 6,000 staff, and provided care through 531,774 outpatient appointments, treating 173,177 Accident and Emergency visitors and admitting 136,633 Patients (University Hospitals Coventry and Warwickshire NHS Trust, 2012).

4.4.1. Infection Prevention and Control

The case study site has a full time Infection Prevention and Control team (IPCT), headed by a consultant microbiologist and managed by a senior matron. At the time of the research the team also consisted of five IPCT nurses, one IPCT healthcare assistant (with specific responsibilities for hand hygiene training and promotion Trust wide) and a dedicated analyst. The team is based on site at University Hospital, Coventry, and carry out regular visits at the satellite site at Rugby (Hospital of St Cross). IPCT representatives are on call regarding IPC issues Trust wide 24/7. The IPCT have a clear sense of shared purpose, manifested through their own aims and objectives (Table 4-2).

Table 4-2: Views of IPCT with regard to their function as part of overall Trust (*reproduced verbatim*)

IPCT views on key roles and responsibilities: eight specific elements
Infection prevention and control practice is an essential component of policy and care
Our role is to produce guidance that reflects evolving knowledge, through research
We collect, monitor and interrogate data which then informs practice
We work alongside staff to produce workable evidence based practice to prevent infection occurring where possible and to reduce risks where it is not
Our responsibility is to both the individual and community, both patients and staff

Our aim is to support and educate staff to make safe clinical decisions that benefit patients and staff by reducing infection rates to the lowest possible
Ensuring that all staff has a zero tolerance approach to healthcare acquired infections
To develop a motivated and questioning attitude from staff to remove complacency

Throughout the course of the research the IPCT offered open access to their resource. This included allowing the researcher to sit in on aspects of hand hygiene and infection prevention training, take part in hand hygiene promotional activities and discuss related infection prevention campaigns being developed and launched by the team (e.g. Get Stool Smart). Such involvement enabled the researcher to develop an understanding of the wider subject area, with the additional benefit of building a strong collaborative environment from which to base the research.

4.4.2. Involvement of Healthcare Professionals from Case Study site

For Studies 1 and 2 Trust wide publicity alerted healthcare professionals to the opportunity to participate in the research through a variety of ways, categorised in the Information Documents as Direct and Indirect participation (Appendix 3a, 3b).

- Direct: participation with a face-to-face element, either through involvement with participatory observation, one-to-one interviews or group interviews.
- Indirect: participation with no face-to-face aspect and involving access and contribution to a research group website.

Following the recommendation of Uwe (2006) meaningful cases were sought when identifying participants:

> [Interviewees] *should have the knowledge and experience of the issue of object at their disposal for answering questions in the interview or – in observational studies – for performing actions of interest.* (pp. 69)

Therefore a target population was identified for specific studies, using guidance from the IPCT Matron, Chief Nurse, Modern Matrons and Ward Managers involved in the research study. This is detailed in each of the study chapters. All Modern Matrons/Ward Managers interviewed were invited to involve members of their clinical teams in further interviews, and given a deadline to respond.

All participants who responded to opportunities to take part in the research, either as a result of publicity or targeted invitations, opted to become direct participants. The option of a research group website was found to be unnecessary, and was therefore withdrawn once interviews had been completed and analysed for both Studies 1 and 2.

Theoretical saturation led to the sample sizes being 30 for Study 1 and 20 for Study 2, as no further recruitment was required after analysis of the transcripts was completed. For this research a process similar to that used by Cavazos et al. (2008) was used to determine theoretical saturation, whereby a specified number of consecutive interviews (in this research two) had to be found to contribute no new major themes for continued sampling to not be required.

Power calculations for Study 3 resulted in 20 participants being recruited. These participants were recruited via their Ward Manager, in a setting that had been identified as suitable during the previous studies. Details as to this process and the participants for each study can be found in each of the Study chapters.

All participants were required to provide informed consent before participation in any of the three research studies, in line with ethical standards of the case study site and national guidelines (see 4.7.3, and Appendix 3f).

4.5. Methods used to conduct Studies 1 and 2

Both interviews and participatory observation were used as predominant methods to explore the current state of hand hygiene measurement, the aim of Study 1. These involved the sample of 30 healthcare professionals, separated into specific groups based on their role within the current audit process, discussed in detail in the Study chapter. Study 2, investigating the potential of technology at the case study site, involved 20 participants. It used interviews, which complimented the two structured literature reviews already discussed (Chapter 3). To maximise efficiency and reduce impact on the case study site, the interviews for both studies were carried out simultaneously, using one session with each participant. Twenty participants contributed to both studies, whilst ten only contributed to Study 1.

4.5.1. Interviews

A semi-structured approach was adopted to conduct the interviews at the case study site. Whilst a more formal, fully structured interview approach may have also allowed information about the current state to be accessed, it may have inhibited the generation of themes, thoughts and opinions from participants which they felt were highly relevant to the function of the current state, yet which had not been included in the interview schedule (Gideon and Moskos, 2012).

Gideon and Moskos highlight the usefulness of interviews for researchers to *emphasize the weakness of their role in the examined society* (pp. 110). As the

purpose of the interviews conducted for Study 1 was to gain knowledge and understanding of a process familiar to the interviewees, yet new to the researcher, this approach allowed a clear distinction between Knowledge Gatekeepers (healthcare professionals) and Knowledge Seeker (researcher).

The use of the semi-structured approach allowed both the researcher and the participant to contribute themes for discussion, whilst the researcher retained control around the overall aim of the interview (Berg, 2012).

For one group of participants (Subjects of Observation: see Chapter 5 for further description) the researcher proposed the use of group interviews for those sharing roles/clinical locations, to allow for discussions to be built, and to reduce potential participant anxiety at being asked views about perceived weaknesses in a process they were not able to change (Uwe, 2006). The term group interview, as used here, differs from that which may be used to describe focus groups, which have an alternative use. Krueger and Casey (2000) identify a key feature of the focus group being their "naturalistic" format, through which emergent views can be sought. An ideal participant group size to achieve this format has been proposed at six-eight (Krueger and Casey, 2000; Patton, 2002). Here, the group interviews maintained the identical semi-structured approach used for the one-to-one interviews, with both featuring three participants each, significantly less than the recommended sample to conduct a productive focus group. Similarly, rather than allow discussion of emergent themes to be the dominant feature of the interviews, as would be the purpose of a focus group setting (Patton, 2002) the researcher ensured that discussion centred on pre-determined topics (Berg, 2012). These

were set out in the interview schedules (Appendix 3d).This proposed method was accepted by all those approached (six participants).

A similar approach was used to discuss the research themes within a pre-scheduled Link Nurses meeting (seven participants). Rather than adopting a focus-group approach, based around discussion and development of themes (Patton, 2002), the data was extracted from this existing meeting using clear, structured probes taken from the interview schedules. Discussion was permitted, but restricted to the topic of the probe, thus elaboration outside of the area was curtailed, as with the semi-structured interview design (Berg, 2012).

A one-to-one interview format was retained for exploring the role of the Consultant within the current state of measurement, due to their differing clinical role, healthcare area, and likelihood of having different experiences to the other participants within the category. The Consultant participant was also kept separate from the remaining participants due to pre-established knowledge regarding the effect of role models within hand hygiene (see 2.6.2.d).

An interview schedule was designed for individuals within each section of the Audit Process Involvement diagram (API diagram, Study 1, Figure 5-3), allowing similar but not identical themes to be examined (Appendix 3d). Probes within the interview schedule were directly linked to a study aim, ensuring relevance of the participants selected (Gideon and Moskos, 2012), topics introduced, and allowing deductive analysis around specific themes to occur.

The order of topics raised followed a standard pattern, however flexibility was ensured to allow movement of probe order depending on the natural pattern of conversation within the interview. All interviews started with an overview of the

reason for the interview and invitation of the participant, culminating in the presentation of the original Current State Map (Study 1, Figure 5-1). This map allowed an explanation as to the research to date, and information as to what topics were to follow e.g. participant's role within hand hygiene measurement process, perceived areas of strength/weakness in the process, role of feedback. Topics relating to the current state followed, before the interview moved on to additional topics being investigated for Study 2. Here participants discussed examples of technologies promoted as being able to improve hand hygiene measurement processes and corresponding behaviour.

Efforts were made to ensure the comfort of the participant, including conducting the interviews in their familiar, relevant workplace (Crang and Cook, 2007), ensuring individual interviews were conducted in private (King and Horrocks, 2010), and building up a rapport through the use of small talk.

Each of the interview schedules were designed to allow topics from Study 1, investigating the current state of measurement, to set the scene for the research by being discussed initially, and Study 2 topics regarding the potential role of technology to be introduced second. Flexibility was enabled through the use of a semi-structured approach with participants able to revisit topics from Study 1 or 2 throughout the interview session.

4.5.2. Participatory Observation

Emerson (2001) outlines participatory observation as emphasising *"close, intimate, and active involvement, strongly linked with the goal of studying others' cultures* (pp. 17-18, in Yin 2011). For this research, participatory observation was

used to achieve what Crang and Cook (2007) define as *intersubjective understandings between researcher and researched* (pp. 37). Having achieved the required step of immersion (Crang and Cook, 2007) via one-to-one interviews with IPCT members the participatory observation stage was developed to allow further context to be added to descriptions of the current state of measurement. Participants were able to provide real-life examples of topics raised in the interviews, and the researcher was able to gain an understanding of the practicalities of conducting measurement within the current state.

Using guidelines from Angrosino (2007) a specific data collection form was designed for Study 1(Appendix 3e). This ensured data could be obtained for each of the seven key categories recommended: 1. Statement about setting 2.Enumeration of participants (number, general demographics) 3. Objective description of participant/s 4. Chronology of events 5. Description of physical setting – all material objects 6. Objective descriptions of behaviours/interactions 7. Records of conversations/verbal interactions.

This form also enabled additional ad-hoc commentary to be documented outside the defined boxes, allowing unexpected issues to still be captured for future consideration. To maintain rapport and comfort of participants, all those facilitating the participant observation (i.e. being shadowed whilst performing data collection) were fully briefed as to the aim of the sessions. They were shown the data collection form prior to beginning the session, and were reassured that their individual practice was not being assessed in any way.

4.6. Study 3

The quantitative element of the mixed methods design came from Study 3, an observational study based within the cardio-thoracic ward at the main site of the Trust, University Hospital, Coventry. Following the mixed methods approach this study built upon themes developed from preceding qualitative work (Studies 1 and 2), and tested emergent assumptions using quantitative measures, as described in the study chapter. Direct observation was used to measure binary data (Yes/No) regarding the hand hygiene responses of healthcare professionals to specific clinical activities. These activities were categorised using a novel framework based on behavioural theory. Field note commentary was used to provide context to the issues surrounding the observations, allowing decisions to be made regarding the appropriateness of inclusion for HHO. This commentary also allowed thoughts and observations regarding development of the method and study design to be captured in-situ, useful at this pilot study level.

Due to the quantitative nature of Study 3 statistical methods were used to analyse the collected data, the appropriate test being a McNemar test of difference. This test allows the difference between related pairs of data points to be tested for significance. For Study 3 the test was used to determine if there was a significant difference between hand hygiene behaviour depending on the activity, categorised based on behavioural theory (i.e. Inherent or Elective).

4.7. Additional Considerations

4.7.1. Triangulation

To defend against the criticism of Researcher bias, Feagin et al. (1991) suggest the triangulative method of case study research increases the likelihood of validity. They propose that the researcher can assemble complementary and overlapping measures of the same phenomenon, and can thus use this to cross-check and validate observations or assumptions. For example, a case study method involving both interview and observational data collection tools can use cross-validation between interviews and observations featuring the same individuals. This was a key feature of Study 1, where to increase the validity of the New Current State Map (Chapter 5, Figure 5-10), direct comparisons were made between the information given during the interviews with the IPCT participants and the later participatory observations carried out with IPCT members performing hand hygiene audits. Follow-up in-situ questions were then asked to clarify any apparent discrepancies between what had been discussed or interpreted from the interview, and what was witnessed or interpreted from the observed audit process.

Triangulation is also heralded as a primary strategy for quality case study design by Baxter and Jack (2008), to allow the selected phenomenon to be explored from multiple perspectives. Furthermore, they add that a post-data collection tool of Member Checking, sending full or extracted samples of research findings back to participants, may be employed to ensure that researcher perceptions agree with the intended projections of those involved in the research. Once again, this is to guard against Researcher bias, and misinterpretation, and was used repeatedly to

validate the New Current State Map, and also in the development of the framework for Study 3.

4.7.2. Thematic Coding and Grounded Theory

All interview transcripts were coded using thematic analysis, designed to extract the key themes from the data. Furthermore, thematic analysis allows for categories to be identified within the data.

Thematic analysis is a key component of Grounded Theory (Strauss and Corbin, 1998), whereby theory is built through the process of research, rather than research being designed to test existing explicitly outlined theories. Whilst it is important to acknowledge that the research design used here does not employ Grounded Theory, due to its use of existing theory and knowledge as a foundation for, (for example) sample selection and interview schedule design, the use of thematic analysis is still required to extract the themes from the data to build meaning and new theory.

A Grounded Theory approach seeks to develop themes purely from an inductive perspective, in that the researcher seeks to follow those themes that emerge from the data. However, Boyatzis (1998) advises that thematic analysis can follow a pattern whereby themes may be generated inductively, from the raw information itself, but also deductively, using existing theory and prior research. In accordance with this the analysis of the transcripts for Study 1 and 2 followed both an inductive and deductive framework. It used topics raised by the participants, through the flexibility afforded by the use of the semi-structure

interview design, as inductive guides, and used the interview schedule probes, based on existing theory and prior research, as the deductive guides.

In addition to deductive analysis generated by previous research, Boyatiz (1998) identifies that the presence of "tacit knowledge" can help the researcher perceive and make sense of patterns in the data, aiding the identification of new themes through inductive means. For Study 1 the use of the participatory observation phase was of key importance to add context to issues raised in the IPCT interviews, and in the formation of themes raised in the interviews with Modern Matrons/Ward Managers and healthcare professionals.

4.7.3. Ethical Approval

Both local (NHS Trust Research and Development: UHCW R&D) and national (NHS Research Ethics Service: NRES) ethical approval was sought and obtained prior to the current research being undertaken (Appendix 3f). Full NRES approval was granted from the West Midlands Committee – Staffordshire. However, regulation changes in September 2011 (i.e. harmonised edition of GAfREC) mean that research solely involving healthcare professionals no longer requires NRES approval. Therefore the research was not required to provide NRES with feedback throughout the duration of the research (Appendix 3f). Communication with the UHCW R&D was maintained throughout the research process.

4.8. Summary

This chapter describes the current research as a mixed methods case study, consisting of three separate studies which employ both qualitative and

quantitative methods in order to address the core research question. Thus whilst the studies presented in the following three chapters have independent aims, methods and results, leading to their own implications and recommendations, combined they are part of one holistic case study designed to meet the challenges of a single research question.

Chapter 5

Exploring the Current State of Hand Hygiene Measurement at the Case Study Site

5. Introduction

To explore the potential for technology to aid with capturing hand hygiene behaviour at the case study site, first the current state of measuring hand hygiene compliance had to be understood. This involved the concept of "Domain Knowledge "being established and utilised. This concept is considered to be the accessing and harnessing of tacit understanding and awareness from those involved in the process investigated (Hovenga et al., 2005), here the hand hygiene audit process (current state of measurement). This chapter presents Study 1, a qualitative study using interviews and participatory observations designed to establish a definitive picture of this current state by using the healthcare professionals involved in the audit process.

5.1. Study Design

5.1.1. Study Objective and Aims

The objective was *To determine the current state of hand hygiene measurement at the case study site and identify strengths and weaknesses of the process as perceived by healthcare professionals.*

This was underpinned by five separate aims (Table 5-1), used to guide research and analysis methods.

Table 5-1: Individual aims underpinning Research Objective for Study 1

Aim No	Aim
Aim 1	Identify tools used
Aim 2	Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
Aim 3	Clarify whether healthcare professionals consider this process to be a burden AND whether they think it has the potential to be improved
Aim 4	Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the burden e.g. would a change of tool help?
Aim 5	Clarify whether healthcare professionals have concerns over data accuracy

Prior to commencing Study 1 a series of meetings were held involving senior members of the IPCT to provide an understanding of the case study site, confirm appropriateness as a setting for the planned study, and gain approval for the research protocol. The existence of a well-established audit process, carried out by a number of different IPCT individuals using a standardised tool yet with apparent scope for individual interpretation, alongside the availability of a stand-alone data analyst assigned to the IPCT, led to the case study site being deemed highly suitable as a research setting.

5.1.2. Original Current State Map

A map of the current state (Figure 5-1) was specifically designed for this research based on a series of initial meetings. This provided a visual representation of the current state, based upon a number of partial descriptions of the way hand hygiene compliance was currently measured at the case study site, and assumptions as to

how data would naturally flow through the existing process. In this research the term “current state” is based on the usage within the manufacturing domain, where “mapping the current state” is a common tool employed to facilitate process improvement, notably within the concept of Lean improvement (Womack and Jones, 2003). A copy of the audit tool being used (ICNA 2004 Hand Hygiene audit tool, see Appendix 1c) was provided to the researcher for initial review, however no details as to how it was applied or interpreted were discussed prior to the onset of the study.

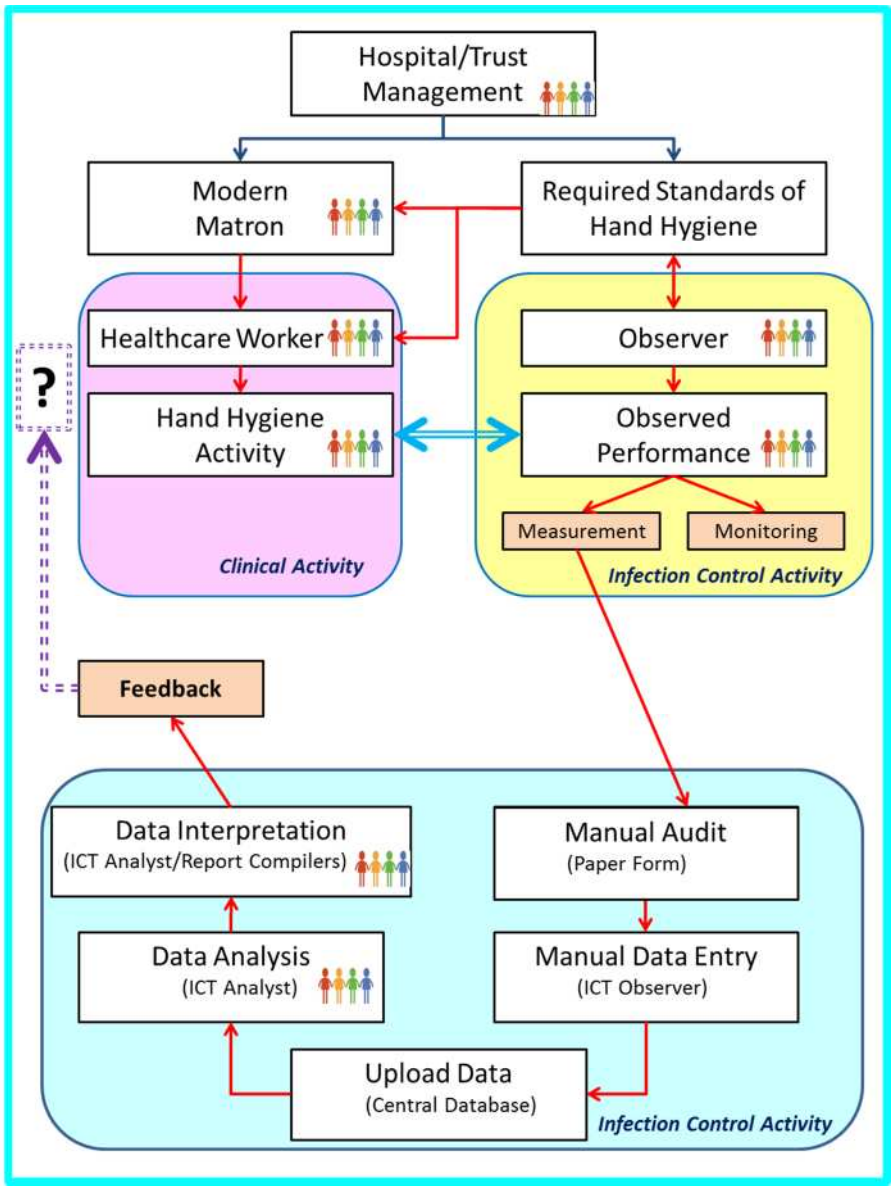


Figure 5-1: Original Current State Map

Study 1 Aims 1 and 2 were directly linked to validating this Current State Map: 1) to clarify exactly what tools were used and how, 2) what the process looked like at the case study site with regard to monitoring, measuring and feeding back hand hygiene compliance performance.

5.1.3. Audit Process Involvement Diagram (API Diagram)

The audit process was considered to involve healthcare professionals over and above those based within the IPCT, who were considered to hold a responsibility

for its management and execution. Based on the initial stakeholder meetings discussed previously, a breakdown of healthcare professional categories was attributed to each of the areas of the audit process, seen as being split into two distinct groups: (i) Measurement and Monitoring, and (ii) Feedback (Figure 5-2).

	API Category			
Audit Process Component	GoD	SoO	RoF	Public/Patients
Measurement and Monitoring				
Perform Audit (Infection Prevention and Control)	✓			
Be Audited (Healthcare Professional)		✓	✓	
Feedback				
Receive Feedback (Direct - Modern Matron/Ward Manager)			✓	
Receive Feedback (In-Direct – Healthcare Professional)		✓		
Receive Feedback (In-Direct - Other)				✓
Produce Feedback	✓			
Disseminate Feedback (1) (ICPT)	✓			
Disseminate Feedback (2) (Direct - Modern Matron/Ward Manager)			✓	
Disseminate Feedback (2) (In-Direct - Other)		✓		✓

Figure 5-2: Measurement, Monitoring and Feedback Roles by Stakeholder Group within audit process *(Key: GoD = Generators of Data; SoO = Subjects of Observation; RoF = Recipients of Feedback)*

To understand how these roles overlapped, for example, how one group may have responsibility for disseminating feedback, yet also be part of the pool whose hand hygiene is the focus of the audits themselves, a Venn diagram was constructed to explore relationships within the audit process (API Diagram, Figure 5-3).

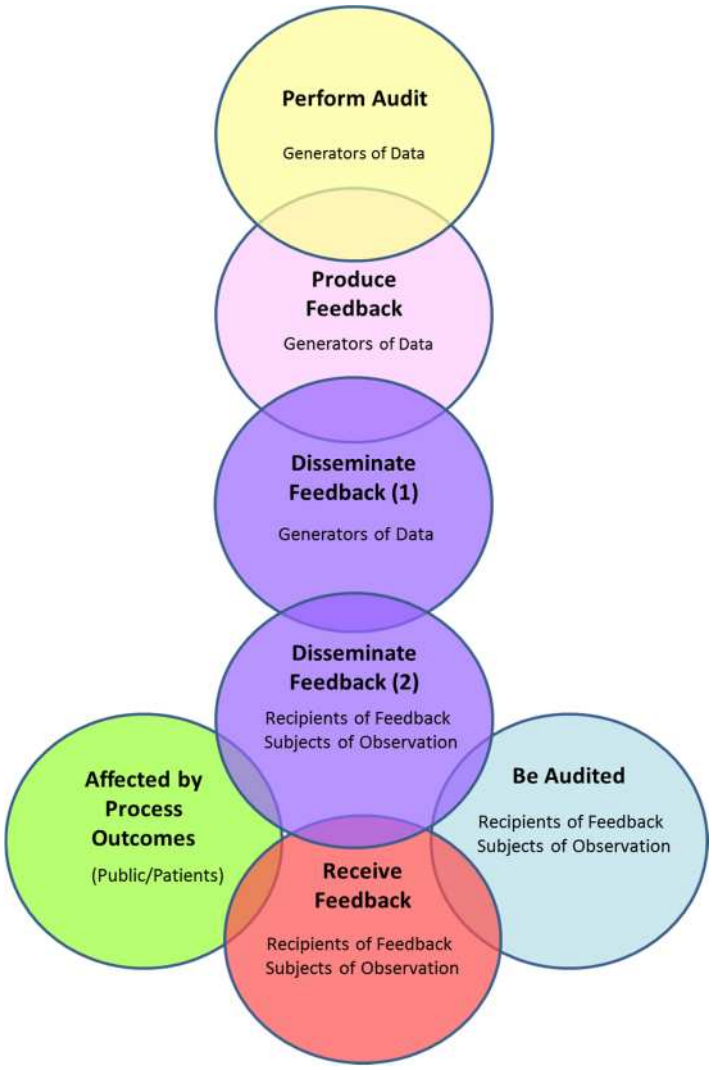


Figure 5-3: Audit Process Involvement (API) Diagram representing relationships between groups with existing audit process at case study site

The API Diagram was generated using the matrix in Figure 5-2. Overlaps between circles represented multiple responsibilities held by API groups. For example, between *Perform Audit* and *Produce Feedback* (GoD), and between *Disseminate Feedback (2)* and *Be Audited* (RoF and SoO).Where circles did not overlap API groups within both circles would not be responsible for performing both tasks. For example, as GoD are not audited by the process, there is no overlap between *Be Audited* and *Perform Audit*.

The use of this process ensured involvement of healthcare professionals in the research, by comprising individuals from all relevant areas of the API diagram. A lack of involvement has previously been identified as risking disfranchisement, posing a potential barrier to implementing any resultant change identified through the audit process, in turn hindering potential improvements in Patient safety (Eccles et al., 1996).

No involvement was sought from those populating the Affected by Process Outcomes pool (Public/Patients).This was because the study focus was the function of the process, rather than concepts regarding potential effects e.g. increased hand hygiene leading to improved Patient Safety.

5.2. Method

Interviews and participatory observation sessions took place between April to October 2012 across both locations of the case study site, involving participants from the three main groups outlined on the API Diagram (Figure 5-3). Additional participants were also involved as identified during the research process.

Figure 5-4 represents the flow of data generation which underpinned Study 1, whereby interviews and participatory observations with the GoD predominantly preceded the involvement of any further sources, to allow an understanding of the current state to be developed by the researcher. Additional interview probes were then integrated for use with RoF and SoO, discussed in full shortly.

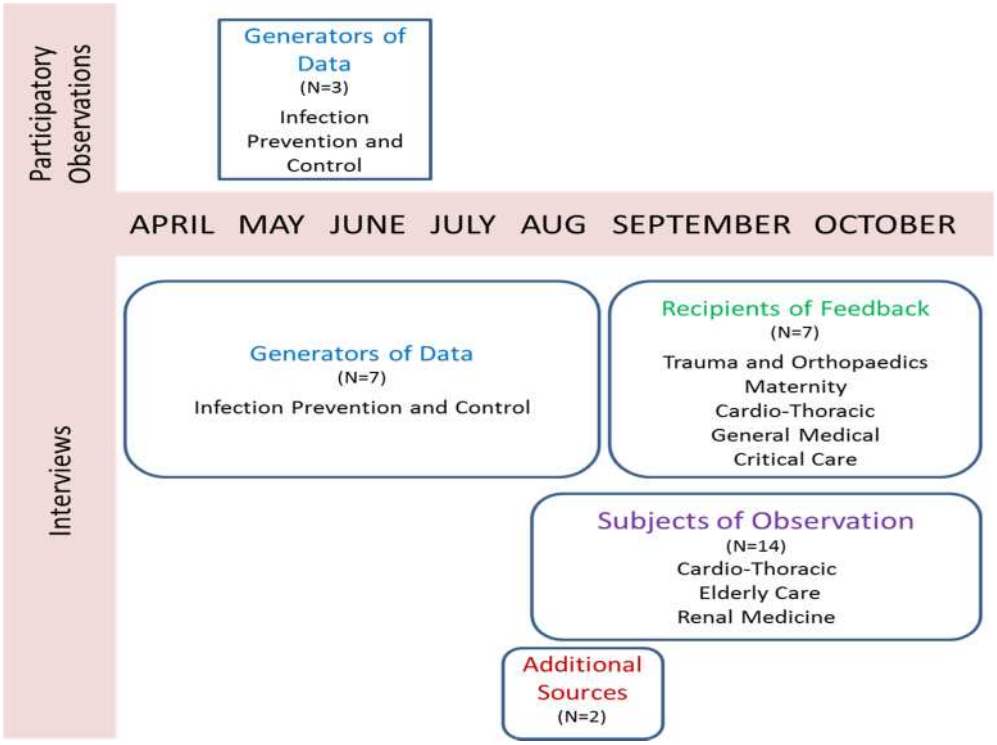


Figure 5-4: Flow of data generation for Study 1 from April to October 2012 employing both participatory observation and interview methods involving GoD, RoF, SoO and Additional Source (AS) participants

5.2.1. Interview Design and Purpose

Interview topics aimed to uncover participant knowledge of the current state of hand hygiene measurement at the case study site, including the participant's role within the process, information about any training they may have received for this role, and their perceived strengths and weaknesses of the tool used for this process. Data from the interviews was used to modify the original Current State Map (Figure 5-1).

As discussed (see 4.5) the research design allowed for both Study 1 and Study 2 aims to be investigated using the same interview sessions, limiting the time and commitment required from the participants.

5.2.2. Interview Sample

Participants from the three main API groups (GoD, RoF, SoO) were interviewed (Table 5-2). The interview process involved: a semi-structured approach, the original Current State Map (Figure 5-1) and purposefully designed interview schedules allowing specific focus on study aims (Appendix 3d).

Table 5-2: Participants contributing to interview phase of Study 1: API group, gender split and interview schedules used (Appendix 3d)

Participant Group	**Number of Participants**	**Number of Interviews**	**Interview Schedules Used**
Generators of Data (GoD)	7 (5 female/2 male)	7	1, 2, 3, 4
Recipients of Feedback (RoF)	7 (6 female/1 male)	6	5
Subjects of Observation (SoO)	14 (13 female/1 male)	4	6
Additional Sources (AS)	2 (1 female/1 male)	2	n/a
Totals	**30**(25 female/5 male)	**19** (15 individual/ 4 group)	

a) Generators of Data: Interview Details

The seven members of the IPCT, identified as the "Generators of Data", were individually interviewed between April and August 2012, to enable an understanding of their role within the current state to be gained by the researcher, and as a precursor and follow-up to the participatory observation stage (Figure 5-4, and see 5.2.4.). The sample size (*N*=7) of GoD was based on inviting all members of the IPCT for interview, and receiving a 100% rate of participant

agreement. The invitation was extended to all members of the IPCT due to previously gathered knowledge regarding the current state of measurement (during scoping meetings), indicating a large degree of individual variation in methods used to complete standardised audits.

Five of the participants were members of the IPCT with individual responsibility for specific areas of the case study site and tasks central to the functioning of the team. Of the two remaining participants one was the Matron of the IPCT, charged with managing and coordinating the day-to-day running of the IPCT, and finally the IPCT Data Analyst, charged with generating, managing and analysing IPCT data produced and required by the team. Four specific interview schedules were used: an identical one for four IPCT members, one slightly different one for the IPCT member responsible for hand hygiene training across the case study site, and specific ones for the Matron and Data Analyst (Appendix 3c).

Except for the Data Analyst interview all IPCT interviews employed a laptop to display a PowerPoint based visual reference alongside the topic probes. This allowed the Current State Map to be presented, and the titles of the probes to be displayed during each segment of the interview. This approach ensured consistency of data provided across all interviews, and provided a separate non-verbal focus for the participant, to reduce any unease they felt with the one-to-one interview format (King and Horrocks, 2010, pp. 53).

Finally those participants who had raised information regarding their physical role in conducting audits within the case study setting were invited to participate in the participatory observation stage (*N*=3).

b) Recipients of Feedback: Interview Details

Five Modern Matrons, one Ward Manager and one Practice Development Nurse were interviewed between September and October 2012 to investigate their role within the current state of measurement, primarily identified as being "Recipients of Feedback". The sample size (*N*=7) was determined by contacting Modern Matrons/Ward Managers from a diverse range of wards, using data from the literature review regarding influences on hand hygiene compliance (see 2.6.2.), and recommendations from both the IPCT Manager and the Chief Nursing Officer of the case study site. The data from Pittet et al. (1999) and other literature reviewed previously (see 2.6.2.a)led to the selection of wards including intensive care and surgical settings. Paediatric involvement was unsuccessfully sought, however Pre-natal and Maternity was included as a related alternative.

The recommendations from the IPCT Manager and the Chief Nursing Officer were based on likely openness to participating in research and known heightened awareness of infection prevention issues (e.g. wards known to recently have had HCAI), making the potential participants highly likely to be meaningful cases for the research (Uwe, 2006).

RoF participants came from the areas of Trauma and Orthopaedics, Maternity, Cardio-Thoracic, General Medical, and Critical Care. The two areas unable to involve in the study were Paediatrics and Clinical Decisions. Upon completion of the six interviews (five individual and one group) no further recruitment in this group was deemed necessary, based upon the obtainment of theoretical saturation (Cavazos et al., 2008).

c) Subjects of Observation: Interview Details

Ten Nurses, three Healthcare Support Workers and one Clinical Consultant were interviewed between August and October 2012, to investigate their role within the current state of measurement, primarily identified as being "Subjects of Observation". Sample size (*N*=14) was achieved through recruitment of healthcare professionals via Modern Matrons/Ward Managers involved in the study, and personal recommendation from the IPCT. Participants came from the areas of Cardio-Thoracic, Elderly Care and Renal Medicine, and from a multidisciplinary team of infection prevention Link Nurses based at the satellite site hospital of the case study site. Upon completion of the four interviews (one individual interview, and one multidisciplinary-based (*N*=7) and two homogenous-discipline based group interviews (two *N*=3) theoretical saturation was met.

5.2.3. Summary of Interview Procedure

Prior to conducting the interview, participants were provided with an Information Document (Appendix 3a, 3b) via email, which they were invited to read at their leisure. With the exception of the Link Nurses group interview, the collection of informed consent (Appendix 3c) was performed with each of the participants at the time of their interview. With the Link Nurses, the IPCT member hosting a monthly Link Nurses review meeting introduced the researcher. Informed consent for generated data to be used within the research was obtained through provision of email addresses and signatures, based on a specific Information Document provided (Appendix 4a).

All participants were interviewed within their own workplace setting, in quiet areas of their clinical context or, for the Link Nurses, within a meeting room at their healthcare setting, familiar to all present. Data regarding specific age was not collected as it was predicted that such information would not have a bearing on requirements of individual roles within the current state of measurement.

Interviews were recorded using an electronic Dictaphone. Notes and verbatim quotes were taken in the Link Nurses meeting (where electronic recording was felt to be unsuitable due to the multifaceted purpose of the meeting), and in two RoF interviews (where electronic recording was unfeasible due to the clinical location).

Following the GoD interviews a laptop was no longer used to provide visual cues for discussion. This was due to the feasibility of using the laptop on a clinical ward, and the growth of the researcher interview skills, allowing rapport with participants to be achieved more quickly than in the initial interviews. Visual tools (e.g. Current State Map) were provided using paper print outs (Appendix 4b).

All interviews concluded with an opportunity for the participant to raise or add topics they felt important to their role within the current state of measurement, and details of how to contact the researcher.

5.2.4. Participatory Observation Design and Purpose

Participatory observation was used as a tool for adding context to the information gathered through the GoD interviews, for validating and developing the New Current State Map, and providing the researcher with experience of the practical challenges of the current method of measuring hand hygiene at the case study site.

5.2.5. Participatory Observation Sample

During the interview process three GoD participants highlighted they were currently responsible for conducted hand hygiene audits across various settings at the case study site. Based upon this they were approached regarding the potential to be shadowed completing this process. All agreed.

Observations were conducted individually with each participant on three separate days. Each participant conducted the process as they would normally, visiting areas of responsibility, and spending the time considered necessary to collect the audit data. The researcher gathered information on a bespoke data collection form (Appendix 3e), and also helped with completion of the ICNA (2004) audit form, to gain an understanding of what this task entailed.

Table 5-3: Details of number and duration of participatory observations undertaken with each participant

Participant	Number of areas observed	Total length of observation (mins)
GoD a	3	130
GoD b	5	103
GoD c	2	118
Total	10	351
		Range (13 – 63)

5.3. Analysis

Data from participatory observation sessions was used to supplement analysis of the interviews, through guiding the formation of categories used on the coding

schedule, and adding further material for discussion, predominantly around the topics of standardisation, and synergy between training and auditing priorities.

All interview transcripts were coded using thematic analysis (see 4.7.2.), designed to extract the key themes from the data. The process of the analysis can be seen in Figure 5-5, and is discussed in detail herein.

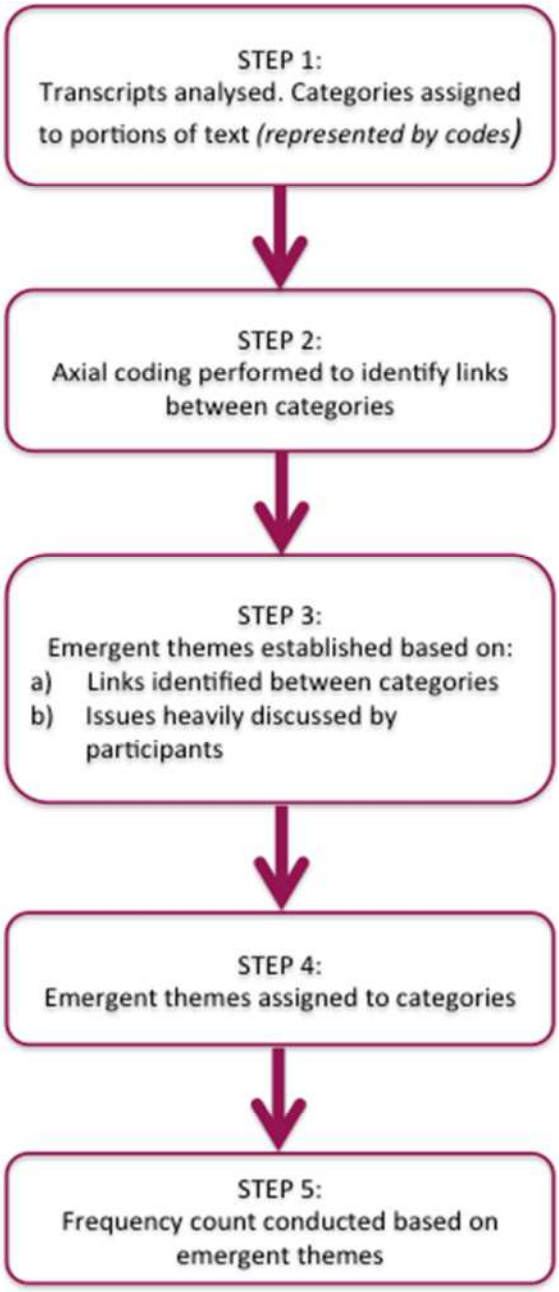


Figure 5-5: Process of analysis conducted for Study 1

5.3.1. Coding Schedule: development and use

A coding schedule was developed, which was then used to extract themes from the data. Each participant contributed data relating to their experience of hand hygiene compliance measurement, using the same prompts (S1/A1-S1/A5). The semi-structured interview approach allowed participants to develop their answers, providing scope for wider discussion. Thematic coding allowed this context rich data to be analysed through categorisation, based on forming relationships between aspects raised by participants. Each interview transcript was analysed in accordance to the thematic analysis approach presented by Boyatzis (1998). Here initial deductive themes are "looked for" in raw data, and inductive themes are noted as they emerge. This process allowed a coding schedule to be developed (Table 5-4).

Each interview prompt ((S1/A1-S1/A5) was used as an initial deductive theme, whilst inductive themes were added as they appeared. Each portion of interview text was assigned a category which represented wither an initial deductive theme, or a new inductive theme. To aid ease of analysis, abbreviated codes representing these categories were used during the coding process (Table 5-4).

Table 5-4: Coding schedule used to analyse interview data, showing initial deductive themes and inductive themes produced from participant transcripts. Categories shown were assigned to segments of text, using the abbreviated codes displayed. Axial coding allowed links between categories and themes to be identified.

Axial Coding Notes	Initial Theme	Category	Codes
	Deductive		
	S1/A1: Identify Tools Used	Audit Tools used - other required standards involved	Audit Tools
	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting	Direct responses to assumptions about the Curent Audit Process - Description, reaction to Current State Map Version 1	The Curent Audit Process - Description, Process Map
		References to individual roles	Role
		References to Individual methods, non-standardisation	Individual Method
		Experience of training to perform the Audit process	Training - Audit
		Experience of training to interpret Audit Data	Training - Interpret
		Experience of training to perform Hand Hygiene	Training - HH
		Specific Hand Hygiene Audit Training (RoF)	RoF HH Audit Training
		Process Map Issues - Discussions of Analysis	Process Map Issues - ANALYSIS
		Process Map Issues - Discussions of Clinical Structure	Process Map Issues - CLINICAL STRUCTURE
		Hand Hygiene Audit - RoF on Feedback Process	RoF HH Audit Feedback
		Discussion of Doctors knowledge of Audit Process	DR Knowledge of Audits
FEEDBACK BURDEN	**S1/A3:** Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved	The Curent Audit Process for Monitoring and Measuring	The Curent Audit Process for Monitoring and Measuring
		Process Map Issues - General Comments about Feedback	Process Map Issues - FEEDBACK - GoD
			Process Map Issues - FEEDBACK - RoF
			Process Map Issues - FEEDBACK - SoO
		Process Map Issues - Discussions of Required Standards	Process Map Issues - REQUIRED STANDARDS
	S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help?	Failings of Audit Process	Failings
		Process Map Issues - Comments about Feedback Interpretation	Feedback Int
		Process Map Issues - Comments about Feedback Use	Feedback Use
		Process Map Issues - Comments about Feedback Meaning	Feedback Mean
	S1/A5: Clarify whether healthcare professionals have concerns over data accuracy	Doctors view of Audit Data Usefulness	DR View of Audit Data Usefulness
		Discussions of Direct Observation problems	Problem of Direct Observation
EDUCATION /FEEDBACK BURDEN		Discussions about specific information about Audit Data	Audit Data/Real Data
	Inductive		
	Overuse of Gloves	Glove Use - Over-Use Opinions	Gloves - Over-use
		Glove Use - When Used	Gloves - Used
	Lack of Education and Feedback Synergy (linked to **S1/A4**) (*link: Not seen as tool per se, but the content of tool not being linked to educational/training priorities i.e. 5 Moments*)	Causes of Burden - Failings of Audit Process Feedback - UNPROMPTED (IPCT)	Feedback Burden (Inductive)
		Education and Audit - not linked	Education Audit unlinked (section in The Current Audit Process for Monitoring, Measuring, Feedback)
	Role Models	Role Models - Unprompted	Role Models - Unprompted
	Workload	Work overload - unprompted	Work overload - unprompted
	Need for public education (view of SoO)	Public education - unprompted SoO	Public education - unprompted SoO
	Concepts of HH (simplicity, difficulty)	Concepts HH	Concepts HH

Initially three GoD transcripts were analysed. Any inductive themes emerging from the data were noted. These were then listed with their respective categories, and the resultant coding schedule was used against the final four GoD transcripts. Inductive themes emerged from the final four transcripts, and were added to the coding schedule.

Primary analysis of the data from both interviews and participatory observations involving the GoD participant group was carried out prior to interviews with the remaining participants. Information from these participants was required to develop interview schedules used in interviews with RoF and SoO participants. A key issue, that of an apparent discrepancy between training priorities and auditing themes (e.g. 5 Moments not appearing in the auditing material) was added into the RoF and SoO interview schedules as a direct result of GoD interviews and examples raised during participatory observation sessions.

The transcripts from the RoF and SoO were analysed using the same coding schedule as the GoD. Inductive themes were added to the schedule during analysis.

Transcripts from all participants were analysed a second time once data collection had been completed, using the final coding schedule, to ensure that themes that had emerged over time were looked for in all data obtained from all participants (Figure 5-6).

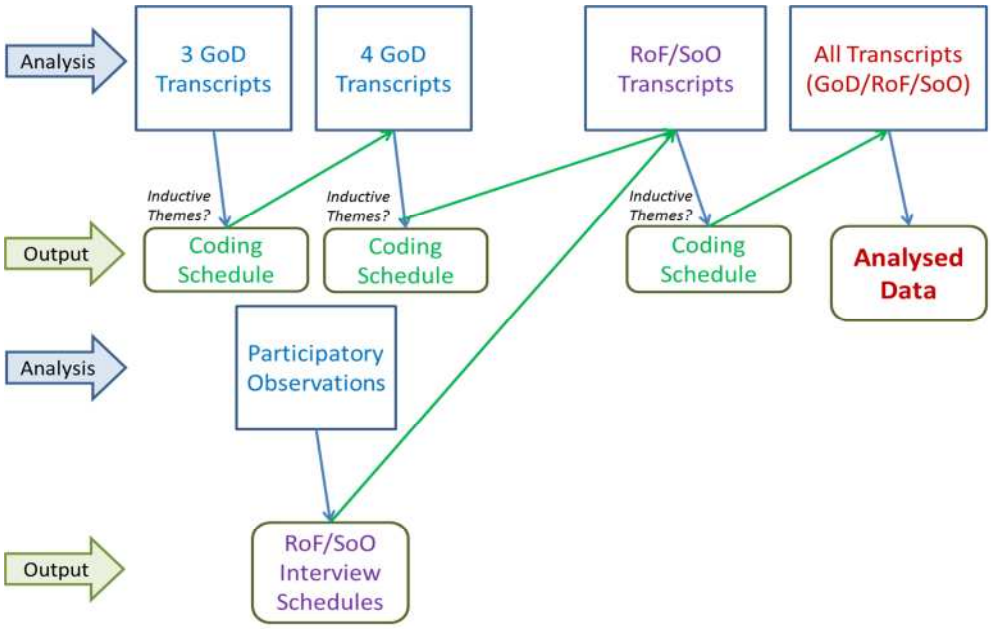


Figure 5-6: Pathway of Coding Schedule development. Refinement of RoF/SoO Interview Schedules influenced by identification of Inductive Themes. Pathway destination = all data analysed using full Coding Schedule

5.3.2. Axial Coding

Axial Coding was performed on the data to allow connections and relationships between the categories to be explored (Strauss and Corbin, 1998; Creswell, 1998). This allowed identification of the link between the inductive theme of *Lack of Education and Feedback Synergy* and the deductive theme of *S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the burden e.g. would a change of tool help?*

Other links, including that between *S1/A3: Clarify whether healthcare professionals consider this process to be a burden AND whether they think it has the potential to be improved* and the aforementioned *S1/A4* highlighted the role of feedback as the predominant perceived burden associated with the audit process (Table 5-4).

5.3.3. Emergence of Major Themes

Following the completion of axial coding the creation of three main emergent themes was possible:

1. Incomplete Feedback Loops/Lack of Clarity with regard to Feedback
2. Lack of Synergy between Training and Feedback
3. Data Accuracy

Some categories related to more than one theme (Table 5-5) therefore each participant quote within each category was assessed to identify which emergent theme best represented it.

Table 5-5: Grouping of categories from the coding schedule to allow identification of three main emergent themes

Axial Coding Notes	Initial Theme	Category	Codes	Emergent Theme
	Deductive			
	S1/A1: Identify Tools Used	Audit Tools used - other required standards involved	Audit Tools	2
	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting	Direct responses to assumptions about the Curent Audit Process - Description, reaction to Current State Map Version 1	The Curent Audit Process - Description, Process Map	1,2
		References to individual roles	Role	2
		References to Individual methods, non-standardisation	Individual Method	1,2,3
		Experience of training to perform the Audit process	Training - Audit	2,3
		Experience of training to interpret Audit Data	Training - Interpret	1,2
		Experience of training to perform Hand Hygiene	Training - HH	2
		Specific Hand Hygiene Audit Training (RoF)	RoF HH Audit Training	1,2
		Process Map Issues - Discussions of Analysis	Process Map Issues - ANALYSIS	1
		Process Map Issues - Discussions of Clinical Structure	Process Map Issues - CLINICAL STRUCTURE	1
		Hand Hygiene Audit - RoF on Feedback Process	RoF HH Audit Feedback	1,2
		Discussion of Doctors knowledge of Audit Process	DR Knowledge of Audits	1
FEEDBACK BURDEN	**S1/A3:** Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved	The Curent Audit Process for Monitoring and Measuring	The Curent Audit Process for Monitoring and Measuring	1,2
		Process Map Issues - General Comments about Feedback	Process Map Issues - FEEDBACK - GoD	1,2
			Process Map Issues - FEEDBACK - RoF	1,2
			Process Map Issues - FEEDBACK - SoO	1,2
		Process Map Issues - Discussions of Required Standards	Process Map Issues - REQUIRED STANDARDS	1,2
	S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help?	Failings of Audit Process	Failings	1,2
		Process Map Issues - Comments about Feedback Interpretation	Feedback Int	1
		Process Map Issues - Comments about Feedback Use	Feedback Use	1,2
		Process Map Issues - Comments about Feedback Meaning	Feedback Mean	1,2
	S1/A5: Clarify whether healthcare professionals have concerns over data accuracy	Doctors view of Audit Data Usefulness	DR View of Audit Data Usefulness	2
		Discussions of Direct Observation problems	Problem of Direct Observation	3
EDUCATION /FEEDBACK BURDEN		Discussions about specific information about Audit Data	Audit Data/Real Data	2,3
	Inductive			
	Overuse of Gloves	Glove Use - Over-Use Opinions	Gloves - Over-use	n/a
		Glove Use - When Used	Gloves - Used	n/a
	Lack of Education and Feedback Synergy (linked to **S1/A4**) (*link: Not seen as tool per se, but the content of tool not being linked to educational/training priorities i.e. 5 Moments*)	Causes of Burden - Failings of Audit Process Feedback - UNPROMPTED (IPCT)	Feedback Burden (Inductive)	2
		Education and Audit - not linked	Education Audit unlinked (section in The Current Audit Process for Monitoring, Measuring, Feedback)	2
	Role Models	Role Models - Unprompted	Role Models - Unprompted	n/a
	Workload	Work overload - unprompted	Work overload - unprompted	n/a
	Need for public education (view of SoO)	Public education - unprompted SoO	Public education - unprompted SoO	n/a
	Concepts of HH (simplicity, difficulty)	Concepts HH	Concepts HH	n/a

This process allowed a frequency count to occur (Table 5-6).

Not all the inductive categories fitted into the emergent themes (Table 5-6). Upon analysis these categories were found to occur less than those contributing to the emergent themes. Therefore, whilst they were acknowledged as being of interest to the wider discussion of hand hygiene compliance (i.e. Overuse of Gloves, see 8.6.), they were not followed up here, due to the specific focus of Study 1 on the hand hygiene measurement process.

Table 5-6: Frequency count of data points relating to each of the emergent themes, and remaining inductive themes

Separate sub-table showing further analysis of emergent themes using API category, highlighting distinctions between perceptions held by participant

(Pp = Participants; GoD = Generators of Data; RoF = Recipients of Feedback; Subjects of Observation; AS = Additional Sources)

			Data Points Contributed			
Emergent Themes	**Data Points**	**Pp**	**GoD**	**RoF**	**SoO**	**AS**
Incomplete Feedback Loops/Lack of clarity with regard to Feedback	40	18	20	12	6	2
Lack of Synergy between Training and Measurement	14	11	9	2	3	0
Data accuracy	21	12	15	5	0	1
Inductive Themes						
Overuse of Gloves	10	12	4	2	6	0
Role Models	9	7	6	3	0	0
Workload	5	5	3	0	2	0
Need for public engagement	3	3	0	0	3	0
Concepts of HH	4	3	3	1	0	0

API Category Analysis	**Data Points**	**Pp**
a) Generators of Data: Where does data go?	11	3
b) Recipients of Feedback: How to use data?	6	3
c) Subjects of Observation: What does data mean?	3	3

Final analysis by API category allowed wider exploration of healthcare professional's perceptions to be considered (see 5.4.3.a.).

5.3.4. Thematic Saturation

The use of the interview schedule, with probes linked to study aims (Appendix 3d), allowed for deductive coding investigating each. Inductive coding returned data relating both to the specific study aims, and to categories which gave a wider context to the objective of the study. This was given structure through the process of axial coding. Interviews were conducted for each participant until thematic saturation was obtained. For this study the experience of two consecutive interviews contributing no new major themes was considered the saturation point.

5.4. Discussion of Results

Study 1 investigated the current method of measurement for hand hygiene compliance at the case study site. Participatory observation and qualitative interviewing methods allowed the five aims of the study to be achieved, with a New Current State Map produced (Figure 5-9; Figure 5-10). Involvement of participants from the three main groups allowed each aim to be explored from the perspectives of those involved in different aspects of the process (Table 5-7).

Table 5-7: Aims with methods for data generation and API groups involved in exploring each *(IN = Interview, PO = Participatory Observation)*

Study 1 Aim	**GoD**	**RoF**	**SoO**
Aim 1: Identify tools used	IN/PO		
Aim 2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting	IN/PO	IN	IN
Aim 3: Clarify whether healthcare professionals consider this process to be a burden AND whether they think it has the potential to be improved	IN/PO	IN	IN
Aim 4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the burden e.g. would a change of tool help?	IN/PO	IN	IN
Aim 5: Clarify whether healthcare professionals have concerns over data accuracy	IN/PO	IN	IN

The three emergent themes are to be discussed within the wider context of how they impact on the current state of measurement at the case study site, namely that they cause a burden.

First, the issue of incomplete feedback loops is to be discussed through the use of visual means, demonstrating how the study data transforms what is known about the measurement process. Secondly, the results of these incomplete feedback loops – a lack of clarity with regard to feedback- combined with a lack of synergy between training and measurement are discussed together, under a global heading of “meaningless data”. This stems from the perception of participants that currently the data produced by the hand hygiene measurement process lacked meaning to them.

5.4.1. Incomplete Feedback Loops: Implications for Current State Map

The original Current State Map (Figure 5-7) was constructed following a series of scoping meetings with stakeholders prior to Study 1 beginning.

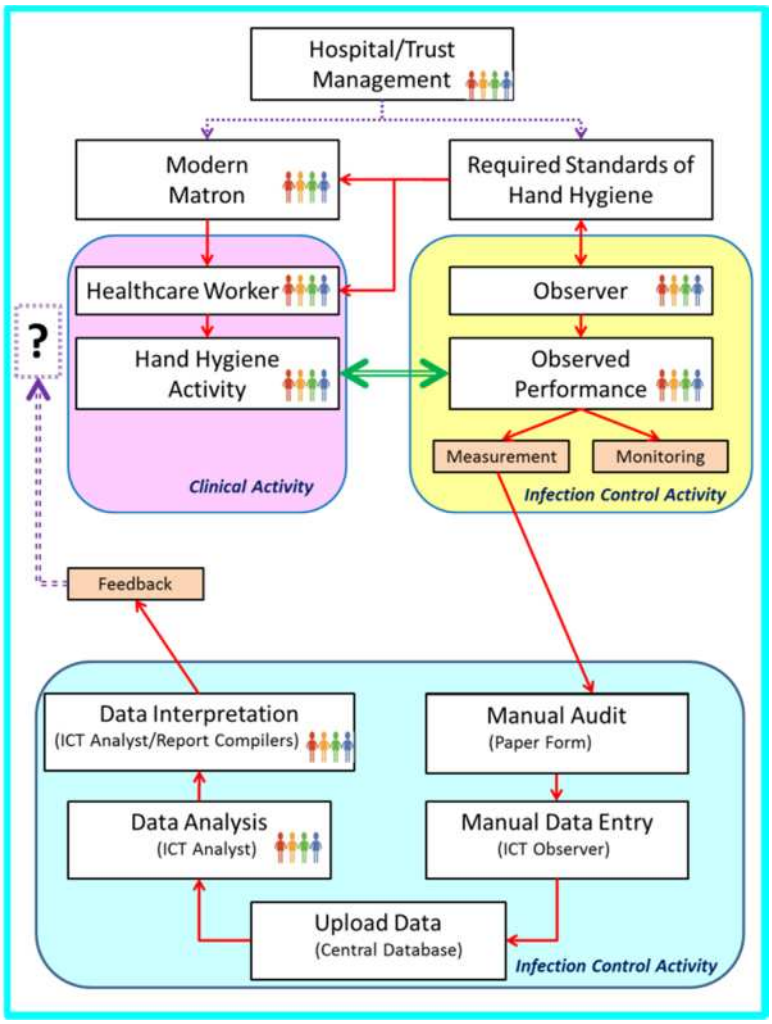


Figure 5-7: Original Current State map as used in Study 1 interviews and participatory observation sessions (see 5.2.)

All seven GoD participants confirmed that the measurement of hand hygiene compliance at the case study site took place using an externally designed audit tool, namely the ICNA (2004) Hand Hygiene audit tool (Section 4.9.) (Appendix 1c). This was further confirmed during the ten participatory observation sessions,

when the ICNA tool was physically used to carry out audits across nine settings, with the researcher having the opportunity to perform the same process.

The interviews and observations revealed that hand hygiene technique is measured according to a required standard, referred to as the Ayliffe technique (modified to an eight-step procedure). This was volunteered (both demonstrated and named) in two of the initial interviews with GoD participants, and then mentioned and/or recognised by 12 of the remaining participants when raised in their respective interviews. Further investigation, facilitated by attending both annual and introductory training sessions (Appendix 4c) revealed this technique to be clearly disseminated to all healthcare professionals during training, with explanations as to the theoretical underpinning (i.e. ensuring full hand coverage for effective decontamination) and appropriateness of using ABHR or soap and water depending on context (e.g. the latter when hands physically contaminated).

Interestingly, as will be discussed later, the WHO *5 Moments for Hand Hygiene* were also discussed during these training sessions, however no explicit reference was found to these guidelines within the ICNA audit tool (due to being published five years before the WHO 5 Moments). Thus they did not form any part of the observational audit criteria carried out by the GoD. Implications for this omission became apparent in discussions regarding feedback.

In Aim 2 participants were probed on their understanding of the current process of measurement of hand hygiene compliance, based upon their specific roles. From the data collected, the main bulk of the New Current State Map was constructed, with changes made to the original version (Figure 5-7) to create the final version (Figures5-8, 5-9). A one-page accompanying commentary was produced based

upon data amassed from the participants, which explained the process map and flow of data. Following the processes of verification (Patton, 2002) and member checking (Baxter and Jack 2008) both the New Current State Map and the commentary (Figure 5-8) were discussed with all GoD and two RoF, to ensure they reflected the process as they collectively saw it.

Two distinct differences emerged from the original Current State Map, referring to:

a) Internal Audit Process
b) Presence of incomplete Feedback Loops

A fuller description is provided below.

a) Internal Audit Process

In the initial interview with a RoF participant (*N*=7) a monthly governance matrix was mentioned, involving auditing of hand hygiene on their specific clinical unit. Following this, all six further participants within this group were asked whether their clinical setting completed this matrix, confirming that it was a Trust wide tool rather than a ward specific process. In terms of internal and external audits, defined previously, this ward level process can be seen as an internal audit on two fronts, not only being carried out at an Organisational level, but also by an individual from within the same ward. This differentiates it from the Trust wide auditing carried out by the GoD (the main focus of the case study) which has a more external aspect, as each ward is audited by an individual who is not from that area i.e. carried out by a GoD. The GoD can be seen as the regulatory body in

this case. Therefore, for clarity, the main Trust wide audit process is known as an external audit in this case study.

A separate process map (Figure 5-8) was constructed to represent this additional internal process.

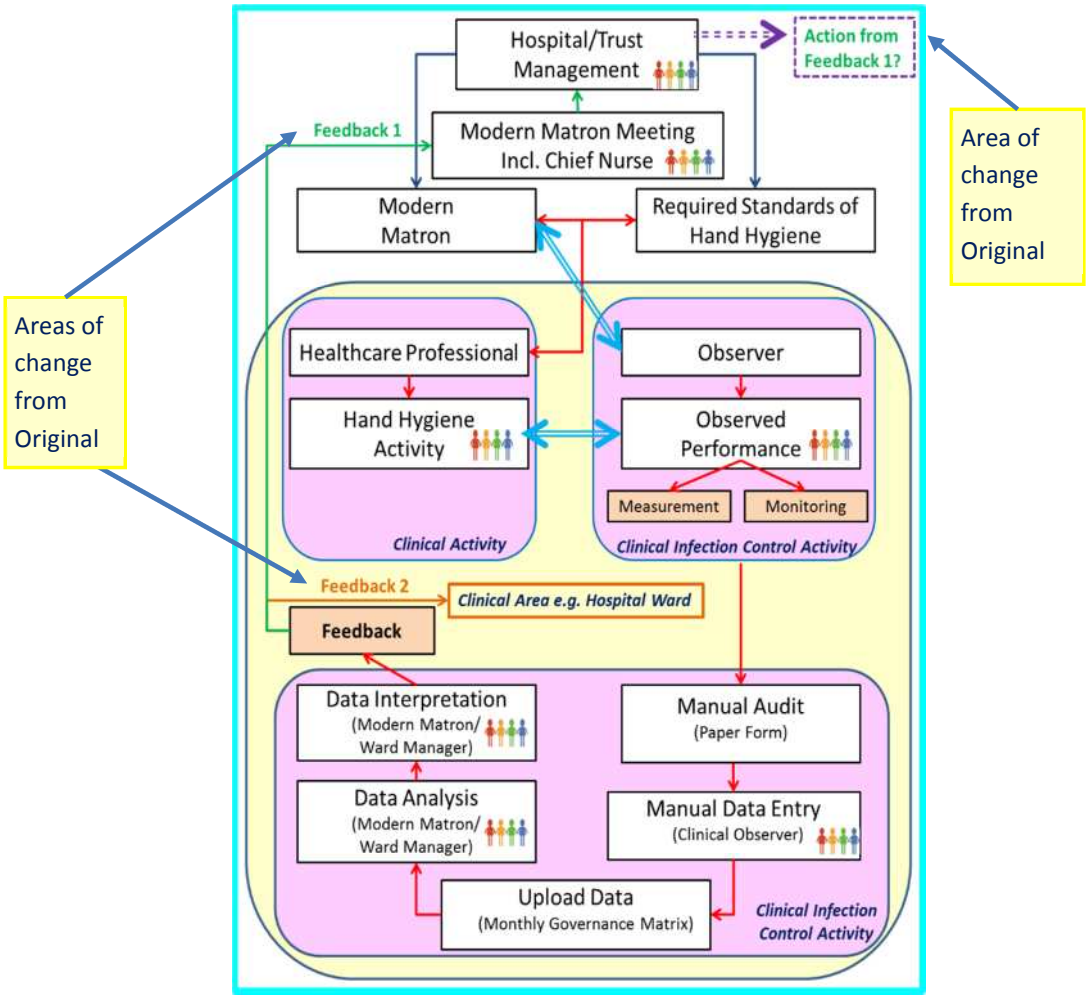


Figure 5-8: Internal Audit Process Map outlining non-involvement of IPCT, dual Feedback loops, and lack of clarity with regard to completeness of Feedback loop 1, indicated by purple dashed lines

All RoF participants confirmed involvement in the governance matrix, including:

> *…on some wards the Ward Manager does it, and on other wards it is the Modern Matron, like here, I do it.* (RoF a)

> *…the audits, we, we do a monthly audit on the clinical areas ourselves. The ward managers will do that, and it's part of something called the Governance Matrix, which looks at various Key Performance Indicators within the area of Quality as well, so it's things along the lines of: has the Crash trolley..?...will be checked, erm, has the Cleaning Book been signed every day? Erm, and then we'll look at hand washing at that point as well. And the staff who complete that are supposed to observe at least 5 members of staff washing their hands, um, and then that's our opportunity to look at jewellery, and technique, um and have they got rings on and so on. Um, so that should be done on a monthly basis and reported.* (RoF b)

Clarification was sought from the GoD as to whether the data collected from this matrix was used as part of their analysis and feedback system, to which the conclusion was negative:

> *The governance framework is another monitoring system that is collected by ward managers monthly it includes hand hygiene but from local data. It differs to that collected on the OLM system. This system sets a target from April to March and not as the DH* [Department of Health] *require for a whole year. This is kept on a separate management drive and is discussed at various forums. Matrons discuss it as part of their quality meetings. It is also made available to commissioners and is defended by the Chief Nurse.* (GoD)

RoF and SoO, whilst clear on how the data was collected, and where it was presented, were satisfied only with regard to feedback internally (Feedback Loop 2). They were unclear on how the data was effectively used to *improve* practice, especially from an external point of view (Feedback Loop 1), leading to an overall perception of meaningless data.

b) Incomplete Feedback Loops

Upon presentation of the original Current State Map participants from all API groups added input regarding the previously unknown feedback process, however this input was predominantly in the form of queries or expressions of confusion:

I didn't realise that bit [feedback loops] *happened…* (GoD)

…they [IPCT] *don't say* "What have you done about this?", *or* "I notice you fell down on all these different areas, have you done something about it?"*…it's just given to us to do whatever we want with it. So you're not always maybe closing the loop.*" (RoF)

[Researcher: *And just to clarify at the moment you don't receive audit feedback?*]
>>I've not seen it… (SoO a)
>>What about the communication books…? Sometimes we get the audits….? (SoO b)
>>Oh yeah, we do get the Infection Control audits, yeah… (SoO a)

This led to the New Current State Map (Figure 5-9, Figure 5-10) featuring blurred lines (dashed purple lines) leading to query boxes regarding the actions of feedback.

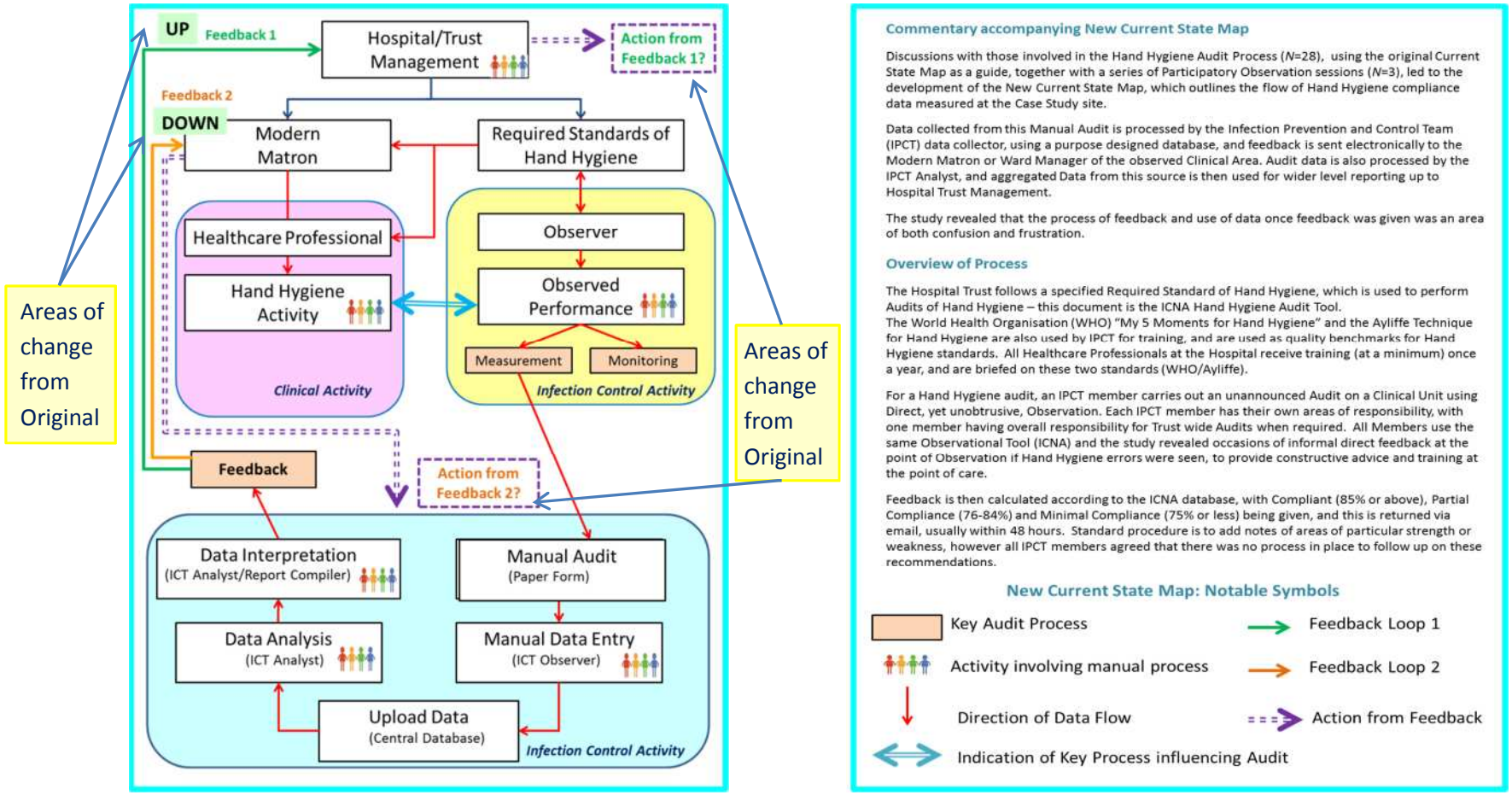


Figure 5-9: New Current State Map (*left*) based upon revisions of the original Current State Map (see 5.1.2.) showing incomplete feedback loops represented by purple dashed lines. Accompanying one-page commentary provided for completion (*right*)

Information was gathered regarding where feedback was submitted, from which a subsequent interview was arranged with the management representative ultimately responsible for defending and actioning this data (Additional Source (AS)):

> *My role on the Board is to provide assurance to them, to essentially the Board itself that we have systems in place to do that. One of the vehicles I have for doing that is the audit process around hand hygiene because it relates to a very core part of our business...making sure we have a clean, safe environment.*

Reliability and confidence in the existing system of audit was voiced during the AS interview, based upon the use of a validated tool (ICNA, 2004), a dedicated IPCT, and the systems of training in place for conducting the process:

> *I suppose there are always, um, concerns about the accuracy of the audit, and the audit system that we have in place…using a validated tool like the ICNA….is one way of reducing one of the variables…having the ICT do it, for me, um, is another way of providing assurance that I get consistency in, in the quality of the assessment, accepting the fact that even within a team as small as ours* [IPCT has 7 members], *there will be individual variation on, on, on reliability…my view would be that, um, the ICT have a systematic approach in terms of training through* [IPCT Matron] *and the leadership, and in terms of, for them to be able to do that role, they would have had to go through a set training process, to do it.* (AS)

However, GoD interviews revealed differing viewpoints, especially in relation to training on how to execute the process. Of the four GoD who discussed their audit performance training two mentioned learning on the job. One discussed previous job history as being their main source of knowledge, the other felt it justifiable to use personal interpretation to explore ways to conduct the process, for example:

> *Well I just sort of shadowed somebody, and they showed me how to do audits, and I did do, the hospital did do like a 1-day training scheme for audits… I've learnt on-the-job…* (GoD a)

> *…you're asking me if I specifically came in and one of the team said to me* 'this is how we monitor hand hygiene'… 'This is how you should be doing it'…*That, that never happened. It was something that I took upon myself, and as a Band 7….I don't think that's wrong. In my remit, if I'm going to go out there and teach it…I need to make sure that I know what I'm doing, and I…I did. So I wasn't concerned. If I had been concerned then I would've asked someone to go through it with me.* (GoD b)

Therefore the conception of a systematic approach in relation to training, as assumed by the management representative (AS), may not be accurate.

A similar contradiction in conception of the current state of measurement emerged during discussions of actions taken with feedback. As discussed, a lack of clarity had been expressed from all participant groups with regard to feedback loops. However, the response from the management source was quite different.
AS expressed a belief of clarity and established procedure that was only mentioned by one other interviewed participant:

> *…as an example,* [if] *we have a number of poor scores in an area that would be flagged to me in a monthly report, or even an ad hoc report…directly from the ICT, um, that would be dealt with at a local performance management framework with the individual Matron…*

The role of feedback, here relating to the data collected during the hand hygiene audits carried out in the current state of measurement, was seen as important by the source, with an understanding of the complexity and additional planning required to ensure a feedback process is effective:

> *…the people who do the audits often get the feedback, and it's that devolving the information out to the people who have been audited… ...so my expectations are very clear that people should feed that back to the Band 2 and the Band 5 on the ward…. Because if I'm trying to affect change, there's very little effect in me going down to the wards and saying "*Your score's rubbish".

> *It might have some sort of Primary Effect……People go* "Oh my God, the [management level] is down here and he's not happy with our score", *but that's not going to be sustained. It's only going to be sustained if the team themselves accept the challenge of poor performance…* (AS)

Again, this information was in some contradiction to that contributed by other participants in all groups, who expressed concern about the lack of involvement of management in hand hygiene data feedback and a lack of awareness of data being fed back to ward based staff. Worryingly this scenario may lead to clinician resistance, highlighted by Bowie et al. (2010), where audit is perceived as futile, especially in cases where data is routinely collected yet seen to be used for managerial purposes, with scant resource being made available to effect identified, required changes.

5.4.2. Creation of New Current State Map

In summary, Aim 2 revealed details underpinning two hand hygiene auditing processes at the case study site, highlighting a key area of uncertainty emanating from all API groups: that of the use of generated data. The remaining Aims pursued this theme further, investigating perceptions of burden and views on individual methods of measurement and interpretation within the current Trust wide process.

Aims 3, 4 and 5, probed the strengths and weaknesses of the current process, based on the ability of the audit tool to monitor and measure hand hygiene compliance, the production and use of feedback data, and the accuracy of any data produced.

5.4.3. Causes of Burden

Two main causes of burden, (i) Lack of clarity with regard to Feedback, and (ii) Lack of Synergy between Training and Measurement, were identified through the interview and participatory observations. Both causes were associated with the role of feedback within the current measurement process. Combined, these weaknesses led to an overall perception that data stemming from the hand hygiene audit process had a tendency to become meaningless. Such a perception is in keeping with the findings of Ivers et al. (2012) who performed a Cochrane Review on audit and feedback within healthcare. They established that whilst evidence regarding the effect of feedback on healthcare professional behaviour was mixed, feedback may be most effective when it includes clear targets and a corresponding action plan.

Issues of data accuracy, both known (related to the manual process) and unknown (related to individual interpretation) were uncovered, and are discussed in terms of their potential exacerbation of the causes of burden presented.

The need for the process to be manual, whilst acknowledged as being time consuming and having expanded over recent years, did not emerge as a major burden.

a) Meaningless Data

Feedback was identified as a major weakness within the current state of measurement by all the groups involved (GoD, RoF, SoO). This led to the New Current State Map having blurred lines to indicate the scope of the problem.

Differences were found between the main questions and concerns regarding feedback stemming from the three groups involved, indicating a potential role-related perception of burden connected to hand hygiene measurement (Table 5-8).

Table 5-8: Main questions regarding hand hygiene measurement data stemming from each API group

API Group	**Feedback: Main Emerging Theme**
Generators of Data	Where does data go?
Recipients of Feedback	How to use data?
Subjects of Observation	What does data mean?

i. Generators of Data: Where does data go?

Five out of the seven GoD interviewed about the current state of measurement volunteered concerns regarding weaknesses about how the data generated by the existing audit process was used. Of the remaining two participants, one did not discuss feedback explicitly in their interview, and the other had a positive viewpoint of the current situation.

Data was perceived to travel in two main directions, *UP* to the management of the Trust, referred to as the Trust, Management or (Exec) Board, and *DOWN* to the areas which the data had been collected from, usually referred to as the Modern Matrons, however also acknowledged to include Ward Managers (Figure 5-10).

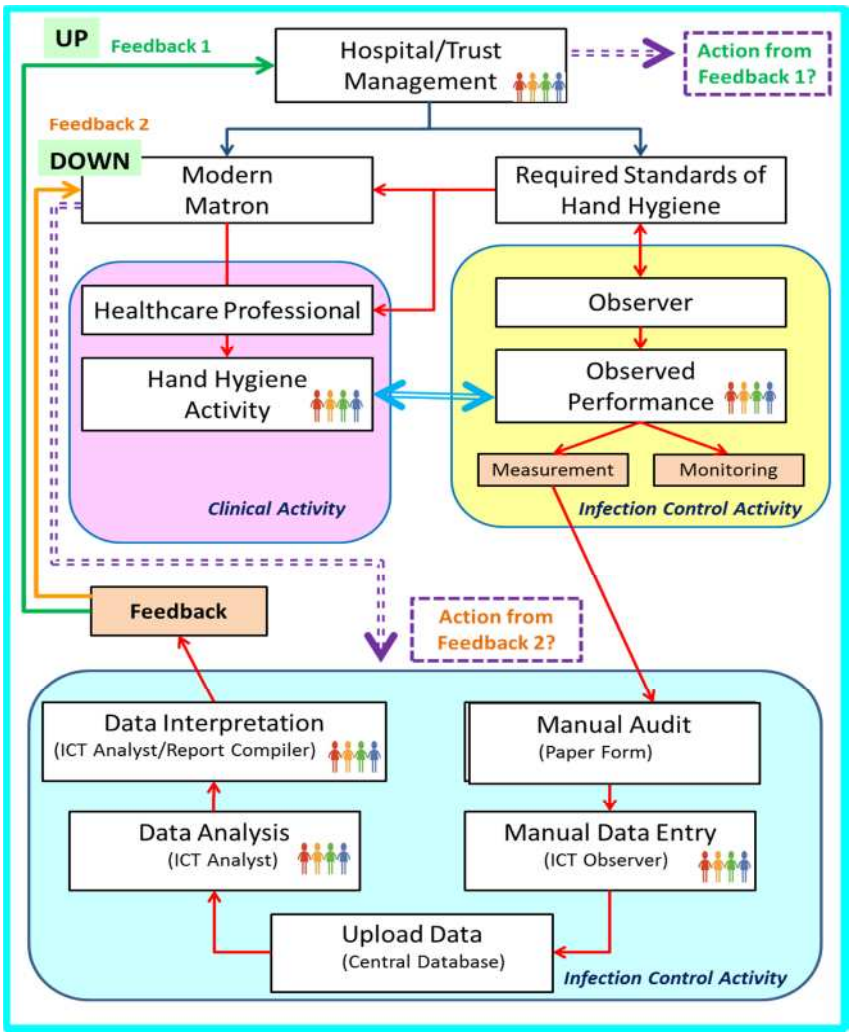


Figure 5-10: New Current State Map with Feedback Loops 1 and 2: seen to represent hand hygiene data flow *UP* and *DOWN* respectively

UP: Feedback 1

A formal reporting procedure was outlined by the IPCT Analyst (GoD), responsible for preparing data as required for all meetings/reports where IPCT (here, hand hygiene) progress is to be discussed:

> *…. we do have a good, um, communication process, I mean we have the various meetings, we have the Infection Control Committee meeting, which is every month as well, so it, and the members of which are from the um, PCTs, as well as the Clinical Directors, um, Associate Divisional Nurse Directors, so quite, quite senior people, so… ... if I was to do, like, a quarterly report on the common themes it would get to those people…*

When probed further, as to whether they felt that this was a successful process, this procedure for UP reporting received a positive appraisal:

> *It would get minuted and everything…it does get recorded. Um, so any actions as presented in the report get minuted, and then we have an action matrix that we've done anyway, so we always have to, you know, close the loop…*

However, frustrations voiced by other GoD indicated that whilst the procedure for reporting may be in place, with data supplied on a frequent, organised basis, the outputs from this data supply appear less clear:

> *…the Exec Board aren't on board, in my opinion...they want the audits, because the Department of Health, we have to comply with certain things at the Department of Health, but the* [xxx – removed for anonymity reasons]*…I've had meetings and* [xxx will] *moderate something to take these things back to your areas, but wouldn't come back in 2 weeks' time and say* "What have you done about it, how have you rectified it?"*, or* "This is the 6th audit that you've failed, your hand, hand hygiene"… "Now what are we going to do?"(GoD a)

> *You fail it, you fail it, you fail it, you fail it. There's no, there's no answer… No one, no one has to stand up there and answer why it still continues.* (GoD b)

This theme of frustration, regarding no apparent action stemming from collected, reported data, carried over to the flow of data going *DOWN* to the clinical areas.

<u>*DOWN*: Feedback 2</u>

> *…you re-audit, and re-audit, and re-audit you find the same things, so I've been in Infection Control now for 5 years…some of the same things come up in the same places all the time….I know there's clinical waste bins at* [Site 2] *that shouldn't be there, they should be domestic. I fed it back when I started at* [Site 2]*, they still haven't rectified it, and in Public toilets over at* [Site 2] *I've got clinical waste bins and not domestic waste bins. For the Public washing their hands. And that is a cost, and that's nearly 5 years, and I have sent email after email and they promise me they'll look into it and they don't.* (GoD a)

This specific example was clarified during the participatory observation with the same GoD. They explained how frustrating it was to have to report the same failings at every audit they did, and used this example to show that this was not only specific to the ICNA hand hygiene audit process.

Finally, the GoD revealed frustration at their own impotence in being unable to provide the solution they knew was required and possible:

> *And I haven't got the remit or cost code to say I want that out, that out, and domestic waste bins put in there…*

Lack of ability to produce change was echoed by other GoD, primarily in relation to the inability in the current process to track if or how audit data was used:

> *…I struggle. You know, you're doing the work…but there's nothing come back from it. Which is a bit frustrating…* (GoD b)

The concept of closing the loop was independently volunteered by three GoD, referring to the lack of clarity with regard to following through on the findings of completed hand hygiene audits. These comments demonstrated an awareness of the audit process, with a central flow of data, as represented in the New Current State Map, yet with the acknowledgement that this process was not complete:

> *I don't think we close the audit loop as, as we should do, really….by getting the action plans back.* (GoD a)

> *We do, we know what needs to be done, we go and audit it, we get the results, we don't ever sort of, really, complete the cycle...* (GoD b)

> *…it sometimes feels from our perspective that although we're carrying out the audits, and we do get the results, they are disseminated back through the Key Performance Indicators… ...Err, to the Modern Matrons, but how they take that back to the wards we never get fed back on – what they've done, or how they've actioned it, to remedy the shortfalls…* (GoD c)

Findings that data relating to “poor performance” or areas “requiring attention”, generates no action appears in contradiction to the understanding of the process discussed by the management representative: *If there is seriously poor performance then there should be an appropriate management framework in place to deal with that, which is what we’ve got.* (AS)

Whilst Zbabada et al. (1998) highlight the issue of organisational subcultures making TQM implementation difficult (e.g. friction between clinical/managerial staff), the issue at the case study site appeared to relate to the process, rather than a lack of willingness by management or clinical staff to use or action available data. However, this notion was not explicitly investigated by the current research.

A standardised approach, discussed shortly in 5.4.4, where following through on feedback is as important as generating the data, may remove the perceived failure to complete the audit cycle. A change in focus from generating data for various reporting loops, to concentrating on demonstrating change from one audit cycle to another may allow management and API groups to have similar understandings of the workings, requirements and practicalities of the measurement process in use. Such a readdressing of focus may be greatly aided by consideration of the Plan, Do, Study, Act (PDSA), also known as Plan, Do, Check, Act (PDCA) cycle, a well establish Quality Management (QM) tool. Evolving from a 1951 model, the Deming Wheel (Moen and Norman, 20??), the PDSA cycle has undergone a number of refinements through the last 60 years, Moen and Norman citing the major influences of Moen and Nolan (1987), Deming (1993), and Langley et al. (1994, 1996, 2009). Robbins (2005) highlights the application of the PDSA in the

world recognised ISO BS EN[12]QM system. The author further explains how this PDSA approach allows each activity to *be planned, carried out, then monitored and improved* (pp. 414). The cycle has been adopted by the NHS Institute for Innovation and Improvement 2006-2013, promoted as a quality and service improvement tool (Figure 5-11).

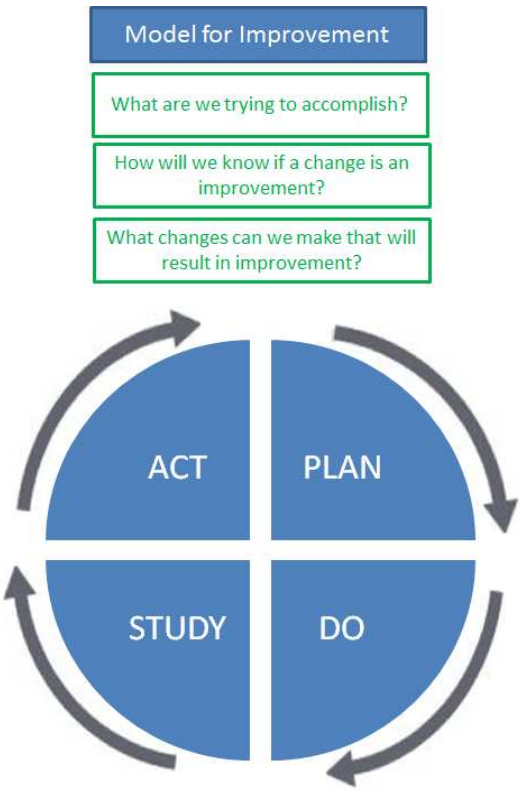


Figure 5-11: PDSA Diagram (*reproduced from NHS Institute for Innovation and Improvement Quality and Service improvement tools webpage)*

Within the *Plan* stage, the appropriateness of any proposed intervention is established, resultant action being carried out during the *Do* stage. Data collected is then analysed and interpreted for meaning during the *Study* stage. Decisions concerning whether roll-out or withdrawal of trialled interventions should occur are made during the *Act* stage (Figure 5-12).

[12] International Organization for Standardization / British Standards / European Norm

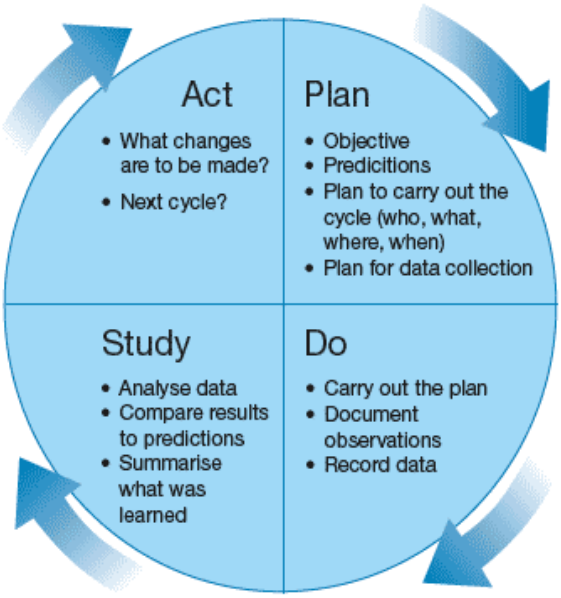


Figure 5-12: PDSA Cycle detailing actions occurring at each stage. New Current State Map revealed predominant focus on the *Do* stage, with data collected and recorded, yet a lack of perceived *Study* activity

Currently, the audit process at the case study site has a predominant focus on the *Do* phase. Data is routinely collected, yet healthcare professionals perceive little focus spent on the *Study* or *Act* stages. The loop is not seen to be being closed.

ii. Recipients of Feedback: How to use data?

The concept of the unclosed loop contributing to a lack of feedback clarity was not restricted to the GoD. The RoF also explained a level of personal interpretation was needed when receiving hand hygiene audit data, and that the process itself could sometimes feel incomplete:

> [Researcher: *You don't get a copy of that actual report* (ICNA tool)*?*]
>
> *>>No. That would be useful actually. Cos I always like to see where you've gone wrong…rather than just getting feedback I like to see for myself what we did…I don't know how it's weighted…* (RoF a)

Here the participant revealed concerns, clarified as *lack of meaning* in audit feedback. Despite information successfully being fed back from the GoD (via Feedback route 2: *DOWN*), they felt they were unable to relate this data to actual instances of practice occurring within their clinical setting. Therefore planning how best to move forward (e.g. interventions, training plans) was not clear. In their qualitative study on the role of audit feedback in combating Surgical Site Infections (SSI), Nessim et al. (2012) found positive feedback from participants about the provision of individualised feedback (specifically data regarding individual compliance to SSI guidelines). Usefulness of being able to link actions with specific outcomes, ability to use data as a prompt to remember (new) interventions, and having an objective measure of performance to enable areas of potential need-for-change, were all documented by the authors as supportive perceptions of individualised audit feedback cited by the participants questioned.

A lack of knowledge as to the weighting of the audit feedback score was also highlighted as an area of confusion by RoF a. This demonstrated how single point feedback (in the form of a percentage corresponding to a grading category, see 2.7.4.c), failed to give meaning in terms of future actions.

The participant reported experiencing a summary feedback approach, with further examples coming from similar RoF working in different clinical areas:

> *I may see the percentage, I don't see a full report – I might see a summary, the good practice or summary of areas of concern.* (RoF b)

> *And then if, with any audit, if we're not compliant with any area they normally send me an email to say that it was a problem – we had staff wearing rings when they shouldn't be, or watches, or that kind of thing….* (RoF c)

These quotes (RoF b and RoF c) indicate an inclusion of key areas of strength and weakness, which would allow meaning to be extracted from hand hygiene audit data, and appropriate remedial planning to occur (action plans discussed by the GoD previously). However, as outlined by a further member of the RoF, and already discussed by GoD, the efficacy of these action plans is unclear:

[Researcher: *Does anybody ever check up on…?*]

> *>>That you've done actions? No. Erm, you have like – I think there is an Action Plan with it…and I think normally what I do is action them, but we just keep them for our own records….I don't know whether all Matrons are the same. Some might do their own and send them back to the Infection Control Team, um, but if we've done alright then they don't seem to come back, but I do seem to find that even if we haven't done alright they don't always come and talk to us…* (RoF d)

Larson et al. (2013) outlines the main predications of audit and feedback as including the presumption that recipients are both willing and able to *modify their behaviour and agree on the goals of change with those delivering the audit and feedback intervention* (pp. 230). The interview data from the RoF participants suggest that at the case study site willingness is apparent. However a lack of communication, through the identified incomplete feedback loops, prevents the able aspect from being possible. The RoF are unable to fully extract meaning from their audit feedback. Further, they cannot be confident that modifications in their behaviours or targets set in their specific areas are related to the objectives and findings of the GoD, tasked with delivering the audit and feedback intervention.

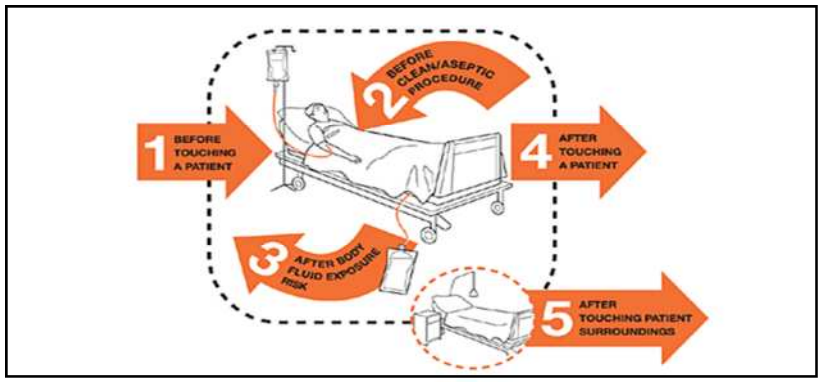
A second assumption outlined by Larson et al. (2013) relates to the specific content of the feedback provided, in that it is often assumed to be *relevant and meaningful and delivered in a way that is readily accessible to the learner and*

that the learner knows how to interpret and act on the results once they are received (pp. 230). This was highly prevalent as a cause of concern to the SoO (discussed shortly) yet is also linked here with the RoF, as both groups of participants contain healthcare professionals who receive audit feedback. In brief, the lack of linkage between the priorities of hand hygiene training within the case study site (i.e. 5 Moments) and the feedback given (predominantly linked to the ICNA points, or only a compliance percentage score), was felt to remove the relevance and meaning of the audit feedback data, and therefore make it unclear to the RoF (and SoO) how to interpret or act upon the provided results.

iii. Subjects of Observation: What does data mean?

All SoO participants agreed that they have access to audit feedback, partially confirming the second assumption of Larson et al. (2013), although this was unclear in some cases and required discussion within a group setting. However the issue of meaning was once again the dominant concern raised.

This concern related to the lack of synergy between two key areas: training and measurement (Figure 5-13). Training priorities (the WHO 5 Moments) had been observed and discussed during specific sessions and GoD interviews (Appendix 4c and a)). Measurement standards (ICNA, 2004) had been observed during participatory observations and discussed during GoD interviews.



4.0 Audit tools 4.9 Hand hygiene 1 of 3

INFECTION CONTROL AUDIT TOOLS

Hand hygiene

Standard: Hands will be decontaminated correctly and in a timely manner using a cleansing agent, at the facilities available to reduce the risk of cross infection

Date ..... **Ward**..... **Auditor**.....

		Yes	No	N/A	Comments
1	Liquid soap is available at all hand washing sinks				
2	Liquid soap must be single use cartridge dispensers				
3	Dispenser nozzles are visibly clean				
4	Soft absorbent paper towels are available at all hand washing sinks				
5	Wall mounted or pump dispenser hand cream is available for use				
6	Antibacterial solutions/scrubs are not used for social hand washing				
7	Antibacterial solutions are used for invasive procedures and surgical scrubs				
8	There are no nail brushes on hand wash sinks in clinical areas				
9	The hand wash sinks are free from used equipment and inappropriate items				
10	Hand wash sinks are dedicated for that purpose				

Figure 5-13: Healthcare professionals at the case study site are trained with high emphasis on the WHO 5 Moments (*top*), yet measurement employs a standardised tool (ICNA, 2004, *extract*, *bottom*) which pre-dates this strategy, thus contains no reference to the training material

SoO were explicitly asked whether they found this discrepancy difficult, if they did not raise the topic themselves (Interview Schedule 5, probe 3, Appendix 3d). Comments from the participants ranged from overall confusion, to frustration and a sense of unfairness about the audit process:

How can you be measured on something you're not trained on…? (SoOa)

No…that's not right. If you're not trained correctly, you can't audit something you haven't been taught…. Because, at the end of the day you would expect your audit results to reflect your training… (SoO b)

I just can't see the point really –everything is 5 Moments, 5 Moments, 5 Moments – but if that's not what we're measured on, then how does anyone know if we're doing it right? I haven't even seen that [ICNA] *so I feel like I'm being cheated…* (SoO c)

Discussions with the SoO suggested a lack of understanding as to how audit feedback could relate to their clinical practice, in terms of the procedures and standards to which they had been trained. As per the API diagram SoO also receive audit feedback, therefore their ability to interpret and act upon results is equally important as RoF, for collectively they make up the same clinical team.

The limitation of the current feedback content being disconnected from the training focus was not lost on the GoD:

I mean, I think for instance, what we need to be looking at now, if we're, we're implementing WHO and the 5 Moments, we need to be reflecting that in our audit…Whilst this is relevant [ICNA, 2004, points 32a-g], *very relevant,* [it] *doesn't reflect what now we teach.* (GoD a)

And being succinctly concluded thus;

...we're harping on about the 5 Moments, but like you say there's nothing in that audit tool to suggest that we're actually looking at anything to do with the 5 Moments… (GoD b)

Therefore a recommended action for the case study site, in order to address this specific issue of imbalance between training and measurement content, would be to consider a change to the use of an alternative measurement tool, which explicitly incorporated the WHO 5 Moments. For example the WHO has an

existing observation tool which has proven to be successfully embedded in a range of contexts on a global scale (Allegranzi et al., 2013; Sax et al., 2012). IPS have recently launched new auditing tools (QIT) with a dedicated hand hygiene section based upon the WHO 5 Moments (discussed further, see 8.2.2.). Whilst a changeover would undoubtedly cause disruption a move would provide an opportunity to ensure previously identified issues regarding standardised training could be addressed, as well as enabling a wider incorporation of global guidelines for hand hygiene into the infection prevention strategy. Resultant data should also, then, possess more meaning across all groups of the API diagram, as it would relate to specific shared aspects of education and training (WHO 5 Moments, Sax et al., 2009).

The importance for meaningful data, related specifically to desired behaviours (i.e. here, following the 5 Moment concept) is discussed shortly.

b) Data Accuracy

A core element of any improvement strategy based on data is ensuring accuracy (Rosof, 2012), especially when data is to form the basis of future improvement interventions (e.g. the *Act* stage within a PDSA cycle, Figure 5-12).

Findings from participants varied according to role, with the most apparent difference being found within the GoD. Here both positive and negative beliefs regarding the accuracy of hand hygiene data were voiced. The Analyst offered confidence in the validity of the data they were provided to analyse, and ultimately fed back via a host of reports, yet other members of the team

highlighting process issues they felt may be affecting the validity of collected data.

i. Known Accuracy Issues

Within the GoD group one individual was identified as being responsible for the co-ordination and analysis of collected data, to identify trends and provide detail for a wide range of feedback mechanisms (including Management meetings, ad-hoc reviews). They were found to have a positive belief in the quality of this data, based primarily on the experience and roles of other members within the team:

> [Researcher: *Do you have any concerns about the data that comes to you? With regard to validity or accuracy?*]
>
> >>*…not really, because, er, since, um,* [IPCT responsible for training] *has been doing them for quite a while now, er, it's, like, it's down to um* [IPCT responsible for training] *really, and* [IPCT Matron] *to double check the validity of the data really.* (GoD a)

However, interviews with GoD responsible for collecting hand hygiene data revealed they felt less confident about the accuracy and validity of the resulting data, primarily due to the well documented issues stemming from the Hawthorne effect (see 2.6.4.d.ii). Revealing comments from GoD members included:

> *…it's all biased, cos they're putting more effort in, to their normal…* (GoD b)

> *They're corrupt. These hand hygiene audits…there's nothing valid about them.* (GoD c)

> *…when people know that you're watching them, they'll do it anyway.* (GoD d)

Within the main and ward based audit processes, RoF also offered insight into awareness of issues they felt may affect the validity of data collected:

I would never pre-announce to anybody here that I'm doing an audit, but they see [IPCT member] *when he comes in, they know what* [they're] *doing…*

>> [Researcher: *And do you think people's behaviour changes?*]

>>*Yep. I'm convinced it does, yeah.* (RoF a)

People definitely perform differently when we're auditing them, and we know that, but you have to accept it. (RoF b)

The concept of internal and external audits was previously introduced, and has been applied at the case study site in terms of differentiating between the internal audit and Trust wide audit (see 5.4.). Whilst there was a perception that observer bias may be higher for the internal process (see 2.6.4.), due to the data collectors having a vested interest in their area performing well, this did not emerge from the interviews. Participants from all groups were more aware of how people changed their behaviour when they were being audited, whether discussing the internal or external audit.

The problems surrounding direct observation have been discussed in detail elsewhere, and these findings indicate that the case study site is no different to other settings: data collected using an observational method is acknowledged to be at risk of validity issues due to behavioural changes. Interestingly, however, Study 1 at the case study site also uncovered that data accuracy may be being affected in additional ways to these known issues of direct observation.

ii. Unknown Accuracy Issues: Lack of Process Standardisation

A key feature of the Quality Management (QM) approach within which the audit process is a tool, is the use of standardised measurement. Within hand hygiene the WHO (2009) and Sax et al. (2009), for example, are very clear on the need for

standardised, validated observational tools and observer training, to ensure consistency in reported measures. Interviews with the GoD revealed that whilst a standardised tool was used for data collection (Aim 1), much emphasis is placed on individual interpretation, leading to a lack of clarity in terms of data collected.

The GoD interviews revealed high levels of personal discretion and individual interpretation were used when carrying out hand hygiene audits. This was confirmed when conducting participatory observations alongside three different GoD. Despite using identical ICNA forms for data collection, the approach and interpretation of the scope of the audit process differed significantly. For example, time taken to complete an audit varied significantly (Table 5-3), dependant on observational opportunities, with each GoD allowing different amounts of time to pass before allotting an *N/A* to an opportunity and deeming the audit completed.

Crucial to this was the individual interpretation around what constituted each of points within the observe practices section of the ICNA form (questions 32a-g, Appendix 1c). When questioned by the researcher the GoD demonstrated high levels of differing opinions as to what would be deemed an activity right to be observed.

For example, there was a discrepancy around defining Clinical Procedures:

> [Researcher: *What is a Clinical Procedure?*]
>
> *>>…probably get a different answer from each of the team…!* (GoD a)
>
> *>>Oh God – there's hundreds...!Setting up an IV line, um, say you were filling up an NG tube into a Patient, aspirating an NG tube... ….<u>Taking temperatures and stuff like that, yeah, observations</u>.*(GoD b, underlining emphasis added by researcher)
>
> *>>…manipulating a urinary catheter in any way, taking blood, changing a dressing……..<u>taking a blood pressure, studying a pulse…... ….… A blood</u>*

pressure…yeah…Whether that's right or wrong…that's my definition anyway... (GoD c, underlining emphasis added by researcher)

>>Clinical procedure I would see as more invasive; like your peripheral cannulas, urinary catheters, management of a central line…if you're changing IV fluids, that to me would be more of a Clinical procedure than Patient Contact… (GoD d)

Naturally many different examples were given, as can be seen from the statements above. However the pertinent issue regarding clarity can be seen when comparing these to a subsequent quote, from a discussion with GoD d, asked to discuss ICNA point 32a *Following Patient Contact:*

[Researcher: *How would you class taking blood pressure, pulse?*]

>>That's more 'Patient Contact', maybe, I would see that as. (GoD d)

Here, the clinical duties of taking a blood pressure or monitoring a Patient pulse (also known as performing observations), are being classified into the 32a *Following Patient Contact* ICNA point. However for other GoD (GoD b, c) such activities had been classified under the 32c *Prior to* /32d *After a Clinical Procedure* ICNA point (see underlining emphasis, pp.218).

Referring back to the definition of auditing (see 2.7.3.) this finding is in contradiction to the concept of audits being *objective, impartial, and independent* and questions whether the case study site is able to use audit evidence *to evaluate how well audit criteria are being met.* The implications of this relates to both the role of feedback and data accuracy. In brief, such discrepancies arguably affect the validity of the collated audit data, as it is impossible to confidently discuss or plan actions regarding hand hygiene compliance at, for example, *Prior to Clinical Procedures*, if the measured data relates in some cases to activities including

(e.g.) monitoring blood pressure and taking a pulse, yet in other instances these duties would be included in a separate category i.e. *Following Patient Contact*.

Individual interpretation was also found to be a feature for the two other API groups, as the interviews revealed no formal or structured introduction to the individual roles within the current method of auditing. In reaction to this lack of formal introduction, those finding themselves part of the audit process, either within the RoF or SoO groups, appeared to use their own initiative to develop methods of interpreting the audit process:

> *I think a lot of it's left then to us to go back and do…really, and it's up to you what you do with it. They expect that we feed it back, erm, which I do.* (RoF)

> *But then it's kind of* if *you chose to read the communication books...* (SoO a)
> >> [Researcher: *So it's, er, personal choice? It's not part of your…*]
> >>*You don't have to tick to say you've seen it, or understood it…* (SoO a)

A further example from another SoO group interview revealed development of a different feedback strategy, again demonstrating the role of personal initiative, rather than any structured or formal feedback process being in place:

> [Researcher: *And who gives you the feedback?*]
> >>*It'd be the boss. In the office.* (SoO b)
> >>*Yeah. Matron normally will get the feedback back from Infection Control, I get an email back from Matron, Matron talks to the Ward Manager, um and then depending on whether – if we've done alright on it then I normally go round and tell the girls how well we've done, and obviously if there's something that needs picking up, um, then they'll bring it up at a ward meeting….I'm here and it's not that often that we fail…much on hand hygiene because I tend to keep a check on them, so…* (SoO c)

This lack of standardisation within the feedback strategy may exacerbate poor efficacy within the use of collected data, with different methods having lesser or

greater impact of communicating performance and required action change. This is not to suggest that standardisation must equate to a one size fits all approach when generating and disseminating audit feedback, as is to be addressed shortly, however it is important as an approach when generating data for valid, meaningful comparison.

5.4.4. Causes of Burden: Implications

Throughout the discussion of the causes of burden the theme of a lack of standardisation has been recurrent. It may potentially lead to mixed interpretations of how the current process of measurement works and contribute to issues of data accuracy, previously unknown by those handling the audit data. Therefore current systems may be perceived as effective by those taking part, however the lack of a singular overall concept of process from those who have ultimate responsibility for ensuring the improvement of hand hygiene within the Trust (i.e. GoD) may be a limiting factor in the effectiveness of the process. The development of the API Diagram (Figure 5-3) offers the opportunity to identify individuals from all areas of the audit process, including clinical and managerial, allowing a more collective approach with singular vision to be developed in the future. Encouragingly, Walley and Gowland (2004) note that the bulk of literature relating to TQM interventions support the notion of management and clinician involvement and commitment, with it being seen as essential for success. Both parties already appear to show commitment at the case study site.

Research by Gill et al. (2011) and Ward et al. (2005) within the healthcare sphere is testament to the importance of relevant data feedback for successful QM strategies. In both cases, the former in neonatal care and the latter in adult care,

reduction of HCAI rates stemmed from strategies designed to fall under a QM approach. Further support for the application of a QM approach, based upon the use of data for improvement, as opposed to simply collecting surveillance data, comes from van Tiel et al. (2006). Here a PDSA cycle was applied to assess practice around defined infection control standards during and after cardio-thoracic surgery to reduce post-operative infection (e.g. wearing of face-masks, removal of jewellery, wound care procedures). Data was compared from a baseline measure with two follow-up measures to demonstrate an improvement in compliance to standards with the authors acknowledging, yet refuting, the limitation of a potential Hawthorne effect. A key recommendation by van Tiel et al. (2006) was the benefit of longer-term monitoring, due to compliance rates fluctuating between the two follow-up periods. This is further supported by Powell et al. (2010) who also highlight the need for longer-term monitoring and trials of TQM and associated QM interventions to fully assess their efficacy. Therefore a system of continued surveillance, combined with meaningful feedback around specific standards, is seen as a potential improvement strategy within infection control. The current case study site already has the resources and culture in place to carry out regular, long term monitoring within the domain of hand hygiene, therefore the provision of a measurement tool which would deliver meaning could be assessed over time using these existing variables.

Of specific importance is the incorporation of all phases of the PDSA cycle, should it be used, rather than the predominantly found scenario of an over-emphasis on *Do* rather than *Study* and *Act* (Walley and Gowland, 2004). This phenomenon, present at the case study site, was characterised by the participants' sense of not closing the loop. Failure to complete audit cycles ultimately limits

their usefulness in engendering change, and therefore the desired aim of improving Patient safety (Eccles et al., 1996).

5.4.5. Meaningful Data: Adaptation of Hysong et al. (2006) Model of Actionable Feedback

In QM measurement data must possess meaning if those involved in the process are to consider it useful. Hysong et al. (2006) used a qualitative approach to compare high/low performing healthcare facilities to produce an emergent model (Figure 5-14). This described variables required for actionable feedback, a term equivalent with the concept of meaningful data used in the current research. In accordance with Larson et al. (2013) both terms infer data that is relevant and meaningful to all receiving feedback. These recipients are then able to both interpret and act upon the provided results.

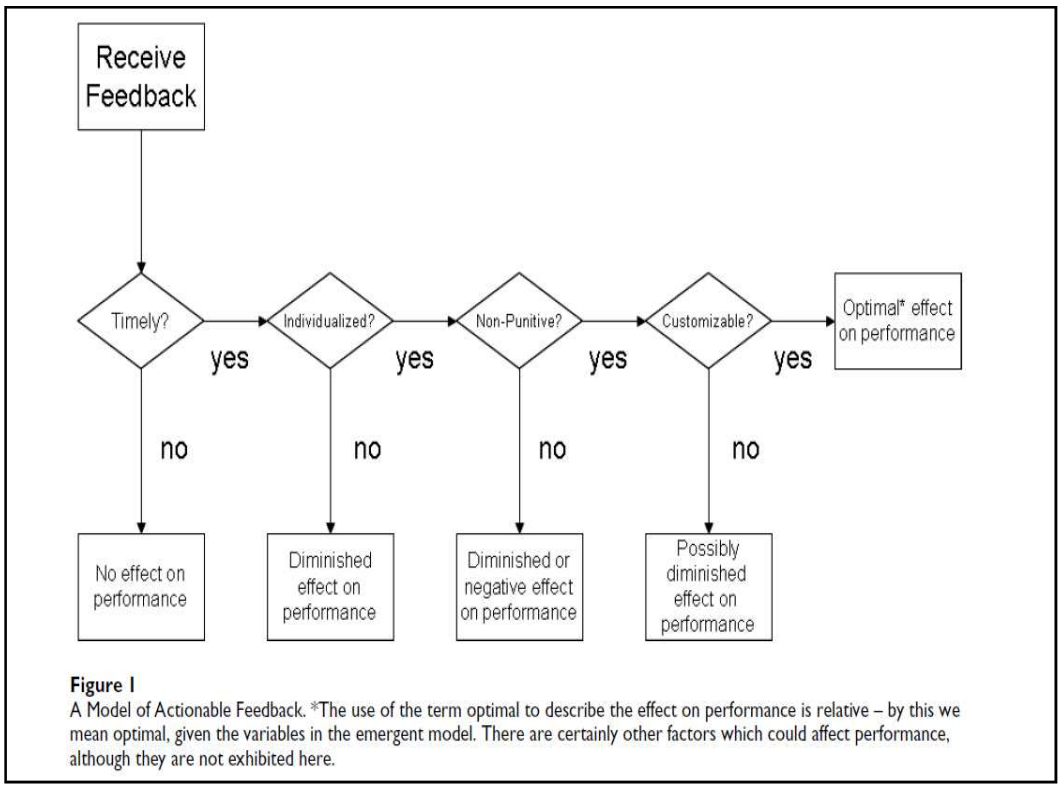


Figure 1
A Model of Actionable Feedback. *The use of the term optimal to describe the effect on performance is relative – by this we mean optimal, given the variables in the emergent model. There are certainly other factors which could affect performance, although they are not exhibited here.

Figure 5-14: Emergent Model proposed by Hysong et al. (2006) outlining variables contributing to the creation of Actionable Feedback

Their model contains four hierarchical variables, required for audit feedback to reach an optimal level of positive effect on performance. Feedback must aim to be timely, focus on individual performance, have a non-punitive attitude and ideally be flexible in nature. This flexibility allows methods to be customisable to enable engagement with the recipient, providing active sense-making rather than a passive data receiving experience. The authors based these variables on their comparison of high/low performing healthcare facilities, with a greater proportion of variables being found in the high performing healthcare facilities than low performing facilities, although no facilities had yet been able to achieve customizability.

Findings from this Study suggest that such a model could be a useful guide in translating the established current process (New Current State Map) into a more effective process, with a suggested working model for discussion presented in Figure 5-15. Currently audit feedback is provided in a timely manner (according to agreed reporting schedules for Feedback Loop 1: *UP*, and within 48 hours for Feedback Loop 2: *DOWN*, however the remaining three variables in the Hysong et al. (2006) model show room for development.

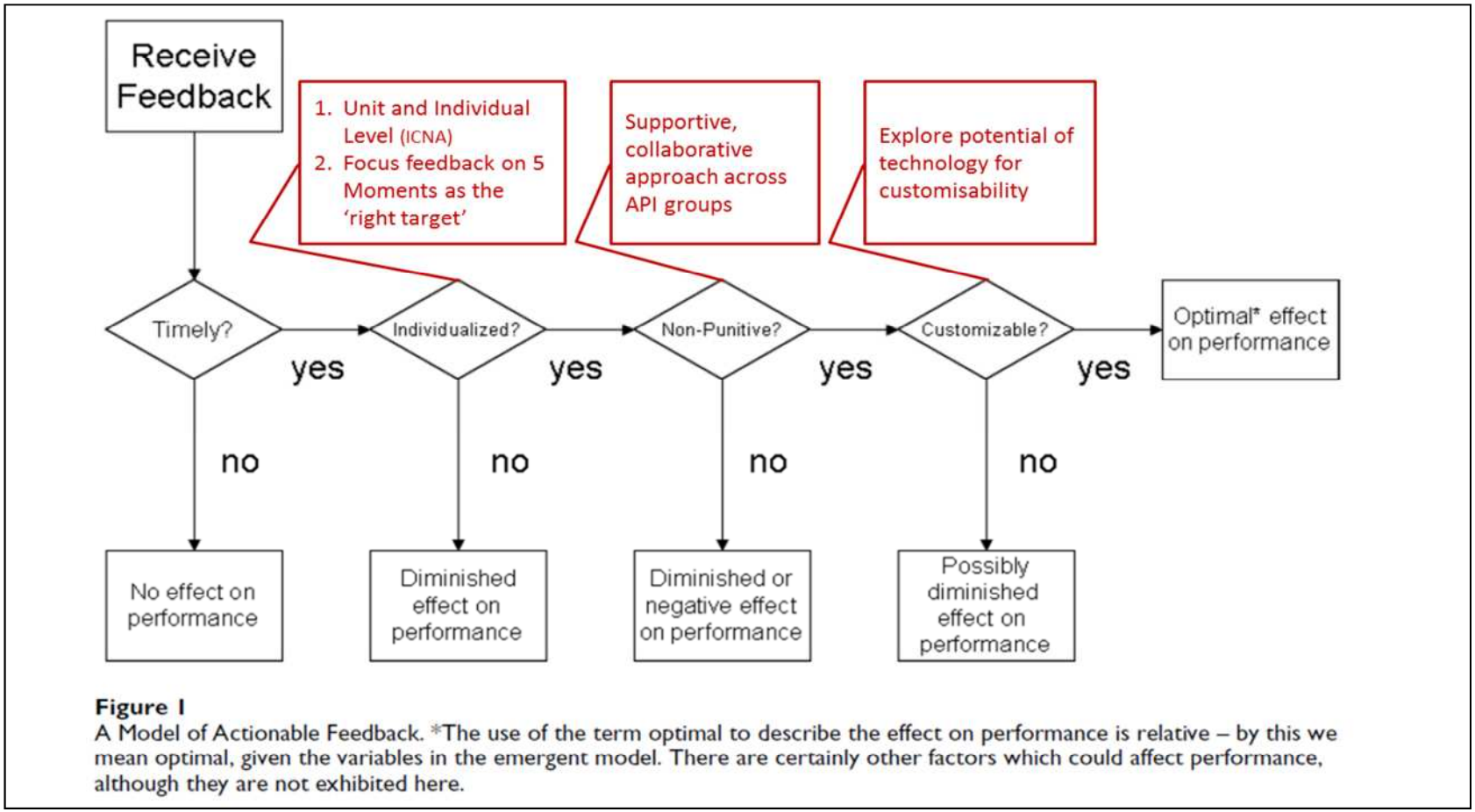


Figure 1
A Model of Actionable Feedback. *The use of the term optimal to describe the effect on performance is relative – by this we mean optimal, given the variables in the emergent model. There are certainly other factors which could affect performance, although they are not exhibited here.

Figure 5-15: An adaption of Hysong et al. (2006) Model of Actionable Feedback (Figure 5-14), proposed as a working model for supporting the development of a new feedback process at the case study site

5.4.5.1. Individualisation: Recommendations for the case study site

In terms of individualisation (Variable 2) Hysong et al. (2006) explain the need for a clear relationship between the level at which data is measured and that which it is fed back to (i.e. those from whom the measurements are taken):

> *Since clinical practice guideline adherence is measured at an individual level (i.e., the data from which adherence measures are constructed concern individual level behaviors such as ordering a test or performing an exam), clinician feedback should be about their individual performance rather than aggregated at a clinic or facility level to maximize its effectiveness.*
>
> (Hysong et al., 2006, pp. 5)

At the case study site hand hygiene compliance is measured based on either individual clinical unit or individual healthcare professional performance. This is dependent on the section of the ICNA (2004) form being completed i.e. Environmental Section; Observational Section; Practice Section (Appendix 1c). Feedback may therefore be more meaningful if designed to be delivered to the level of measurement, be that the clinical unit or healthcare professional.

An informal feedback practice was identified through the participatory observations sessions and interviews involving both GoD and RoF:

> *I always speak to the staff, so any instances that people aren't, um, aren't complying I don't just do my audit I go and speak to the staff at the time…* (GoD)

> Feedback is given directly to the team, but is given to the individuals at the time by the ICT/Ward staff member, whoever is carrying out the specific audit. [Researcher notes from interview with RoF, electronic recording not available]

This finding implies that a new process, formalising this approach and incorporating it into a standardised process, would be possible and beneficial, allowing maximum benefit in terms of potential improvements on hand hygiene compliance performance.

Incorporation of the WHO 5 Moments would be ideally suited to this proposed new process, with individualised feedback to healthcare professionals referring specifically to their 5 Moments hand hygiene training. Such feedback was observed being undertaken by all three GoD participants carrying out audits during the participatory observations, and by incorporation into a standardised process such practice could be expected by the whole team.

Furthermore, a move towards using a 5 Moments measurement tool, for which interest was shown by the GoD (discussed further in Chapter 8) would allow unit level data on overall performance at these key areas of hand hygiene compliance to be fed back to the RoF, and in turn the SoO, which should aid those receiving the data to find a greater level of meaning than they currently perceive. Having this data linked directly to their training principles should, according to both Larson et al. (2013) and Hysong et al. (2006) allow the case study site to interpret and use the audit feedback data, finding that it now becomes actionable, rather than meaningless.

5.4.5.2. Non-Punitive: Recommendations for the case study site

Hysong et al. (2006) include non-punitive as their third variable, with two of the three high performing healthcare facilities explicit in their approach to not be punitive when delivering feedback, as opposed to explicit reference of negative,

punitive attitudes employed at one of the low performing facilities (remaining facilities provided non-directional evidence regarding this variable).

The current study did not explicitly explore the theme of feedback style (i.e. punitive vs. supportive), however no overtly negative examples or themes relating to feedback attitude were either observed or emerged through the interview process. The omission of negative issues relating to feedback being raised for discussion by participants was considered. However, as the researcher spent a significant period of time with participants the concept of such participant bias, displaying only behaviour designed to please the researcher, was deemed unlikely. This was considered particularly doubtful considering a lack of hesitancy to provide examples of other areas of perceived weakness with the current state of hand hygiene measurement at the case study site. Such behaviour implied an ability to provide a less than perfect picture to the researcher.

As discussed, the main frustrations for all those identified as having API related to incomplete feedback loops and meaningless data, rather than from perceived frictions between API groups. The prospect of more feedback was often welcomed, and the existing system of action plans employed at the case study site may enable collaborative, supportive use of data for improved practice.

5.4.5.3. Customisability: Recommendations for the Case Study Site

Customisability was defined by Hysong et al. (2006) as the *ability to view performance data in a way that was meaningful to the individual provider.* (pp. 5). This was seen by the authors as the final variable completing their model, thus achieving the desired goal of actionable feedback for an optimal effect on performance. Of the six healthcare facilities included in their study (three high

performing, three low performing) none reported use of customisable feedback mechanisms. However the possibility of such systems was reported in *some* (number not specified) high performing facilities. Interest in the capability to provide this resource was reported from both high and low performing facilities.

At the case study site discussions with the IPCT Analyst (based within the GoD) suggested that customisability is both possible and is executed as part of the routine handling of data within the current feedback process, with specific reports and investigations relating to the data being carried out upon request:

> *Say 98% of the hand hygiene was good, but if* [IPCT management] *wants me to delve deeper into what the common themes that keep, that they keep on failing across the wards, then* [they] *would ask me.*

Further exploration of different methods currently employed by both RoF and SoO to interpret and disseminate audit feedback may offer interesting insight into opportunities to customise feedback specifically to unit level. The efficacy of these approaches could be explored, with the appreciation that what works in one area may not be suitable for another (Gardam, 2013).

Due to the previously identified and discussed problems with incomplete feedback loops, and the lack of clarity with regard to feedback data, the opportunities available to customise feedback may not currently be being used to its full potential. Certainly findings leading to the output of the New Current State Map indicate that whilst data may be being delivered to senior management (Feedback Loop 1: *UP*) via customised, prepared reports, or to clinical areas (Feedback Loop 2: *DOWN*) via unit specific action plans, it is the lack of perceived action from these reports that is a major source of frustration to the GoD, seen as a major cause of burden and hindrance to improved performance:

We don't follow up any actions that we've found, necessarily. Anything that we've found from the audit we don't necessarily chase that up… (GoD a)

That's one of the frustrating things about our job. That's what, cos, cos we haven't got, erm, Exec support – we used to. (GoD b)

I think, when we're finding the same issues, and we are *finding the same issues, when you speak to* [IPCT Analyst] *you'll see that, non-compliances around the same things. Um, we never, we never, we never finish the loop.* (GoD b)

Removal of such burdens, through a focus on closing the loop and investigating causes of perceived lack of empowerment for change (e.g. lack of Executive support) are likely to be a fundamental need if the benefit of customisable data, outlined by Hysong et al. (2006), is to be felt at the case study site.

5.4.6. Meaningful Data (Actionable Feedback): Prospective Future State for Case Study site

With clear feedback loops and the ability to perform required changes, these findings suggest that the case study site would have the potential to move towards an audit feedback process encompassing all four variables outlined by Hysong et al. (2006). Data is already analysed and feedback delivered in a timely manner (usually within 48 hours), and indications from current informal feedback practices suggest that individualisation of data could be adapted into a standardised approach. Ensuring the feedback process remains non-punitive, and collaborative, with recognised and shared goals may have the additional benefit of encouraging a loop closing culture. However current issues of a perceived lack of executive support would need to be addressed with priority for meaningful change to occur. Finally, customisability via the availability of an IPCT Analyst and an existing interest from participants across the API groups in the meaning of the

data, suggests that this area of the audit process has strong developmental potential. The widening of focus, using a PDSA cycle approach may enable the future state to change from a strictly auditing-to-collect-data (*Do*) stance to measuring-to-enable-change (*Study*, *Act*) position. Combined with the steps proposed to ensure that generated feedback would be meaningful for all involved in the process, the prospective future state for measurement of hand hygiene at the case study site is arguably positive.

Further, the potential for the involvement of technology, the focus of the next study (Chapter 6) may offer useful tools for engagement and analysis to achieve the goal of actionable feedback as proposed by Hysong et al. (2006), delivering useful, meaningful data that can be interpreted and acted upon as recently recommended by Larson et al. (2013).

5.5. Study Limitations

Whilst the study involved individuals from all sections of the API it is acknowledged that the sample only contained one consultant, and no doctors, with the remaining participants either being nurses, healthcare support staff, IPCT members or having specific managerial/administrative roles (i.e. Director of Nursing/Practice Facilitator). As past literature has shown that role has an effect on hand hygiene behaviour (see 2.6.2.d) the lack of representation from these quarters may be a limitation of the study. However participants were included based on their fit within the API groups, rather than their professional role. The interview schedule probes (Appendix 3d) focused on the current role of the individual within the audit process, and their knowledge of it, as a representative of the API group, rather than as a representative of their professional category.

This, along with the successful obtainment of theoretical saturation, may suggest that the sample mix was not a major limitation to the study outcome.

It is acknowledged that the sample size (*N*=30) represents a very small proportion (0.5%) of the staff employed at the case study site (6,090 entire staff, including non-clinical). However following the guidance of Seale (1999) and Shavelson and Townes (2002) the objective of the work is to provide analytical rather than statistical generalisation. Here an emphasis is placed on providing a detailed descriptive overview of the chosen context, including sample selection, allowing external readers to intuitively decide whether emergent proposed themes could be expected/recognised within settings known to them, based upon likely similarities. In terms of generalisability the goal of the research is the ability to be able to generalise the findings to theoretical propositions, which other individuals and researchers can then use and consider going forwards.

5.6. Chapter Summary

Study 1 established a New Current State Map based on the exploration of the process of monitoring, measurement and feedback of hand hygiene behaviour currently employed at the case study site. All five study aims were achieved, through a combination of interview and participatory observation, allowing a greater understanding of the process, including perceived burdens, from the viewpoints of the three main groups of individuals involved in the audit process.

The critical themes emerging from the study related to validity of measurement, a lack of clarity and consistency in content of audit feedback and the lack of synergy between training content and content of audit feedback data. The

identified weaknesses within these critical themes led the majority of participants (*N*=22/30) to conclude that audit feedback data at the case study site is often meaningless. Through the use of an existing model of audit feedback, Hysong et al. (2006) Model of Actionable Feedback (Figure 5-14), recommendations for overcoming these perceptions of meaningless data and existing process weaknesses were proposed, leading to an adaptation of the model (Figure 5-15) and recommendations for a prospective future state.

The potential for the measurement of data, with additional focus on creating meaning, through the use of technology became the focus of Study 2.

Chapter 6

Investigating the potential for Hand Hygiene Technologies at the Case Study site

6. Introduction

Following Study 1, the potential for technology to improve the efficiency and accuracy of hand hygiene measurement was investigated, specifically focussing on whether technology may be able to provide meaningful data.

6.1. Background to Study

Study 1 revealed two perceived burdens relating to the current state of measurement at the case study site: (i) Lack of clarity with regard to Feedback, and (ii) Lack of Synergy between Training and Measurement. Compounded by data accuracy concerns, these contributed to the majority of participants (*N*=22/30) concluding that audit feedback data at the case study site is often meaningless.

Study 2 was based upon the findings of two separate literature reviews (Chapter 3) investigating current technologies aimed at measuring hand hygiene compliance.

The initial literature review (see 3) identified a range of current technologies aimed at the measurement of hand hygiene, a sample of which were used to investigate healthcare professional's views on such technologies at the case study site. The second literature review (see 3.3.), investigated the Fit For Purpose of technologies currently being promoted for measurement of hand hygiene compliance. This allowed discussions regarding their achievement of measurement at the WHO 5 Moments, and the generation of meaningful data.

6.1.1. Study Objective and Aims

The objective of this study was: *To explore the view of current healthcare professionals on the potential for technology to measure, monitor and feedback hand hygiene compliance to the WHO "My 5 Moments for Hand Hygiene" in an NHS acute setting.*

To achieve this objective five separate aims were established (Table 6-1).

Table 6-1: Individual aims underpinning Research Objective for Study 2

Aim No	**Aim**
Aim 1	Determine whether any current technologies available measure/monitor hand hygiene at the WHO 5 Moments
Aim 2	a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with
Aim 3	Using existing case study site hand hygiene audit data identify potential areas where compliance appears particularly a problem Does this relate to healthcare professional perceptions (Aim 2)? Is there potential for technology to develop a solution?
Aim 4	Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of hand hygiene compliance in their setting?
Aim 5	Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?

6.1.2. Technology Examples

From the initial literature review four categories of technology "Types" were established. The other category was re-analysed. Technologies in this category were found to be unsuitable for auditing as they could not provide measurement at an individual level, and therefore the category was removed from the review. This left three main categories, totalling ten technologies with individual based monitoring capabilities (Table 6-2). An example from each category was selected (based on availability of detailed usage descriptions) and used to aid discussion of hand hygiene technologies with participants (Appendix 2a).

Table 6-2: The ten identifiable technologies split into three main categories from which examples were drawn for discussion with Study 2 participants

Type of Technology	**Overview**	**No. of Examples**
Healthcare Professional Badge system	Worn data collection devices, using tracking ability to measure individual levels of compliance	3
Healthcare Professional Dispenser system	Worn data collection devices issuing decontamination aid, ability to measure individual levels of compliance	2
Healthcare Professional Surveillance System	Complex systems able to monitor and measure hand hygiene activity within specified area	5

6.2. Method

6.2.1. Interview Design and Purpose

Interview topics aimed to probe participant views on how hand hygiene was measured at the case study site, specifically based on the challenges of manual practice and views on technology examples. The process for interview used: a semi-structured approach, examples of technology types (Appendix 2a) and interview schedules allowing specific focus on study aims (Appendix 3d).

6.2.2. Interview Sample

Participants from the three main groups identified through the API diagram (GoD, RoF, SoO), were interviewed (Table 6-3) (the same participants as for Study 1).

Table 6-3: Details of participants contributing to interview phase of Study 2, including originating API group, gender split and interview schedules used

Participant Group	**Number of Participants**	**Number of Interviews**	**Interview Schedules Used**
Generators of Data (GoD)	6 (5 female/ 1 male)	6	1, 3, 4
Recipients of Feedback (RoF)	7 (6 female/ 1 male)	6	5
Subjects of Observation (SoO)	7 (6 female/ 1 male)	3	6
Totals	**20** (17 female/ 3 male)	**15** (12 individual/ 3 group)	

a) Generators of Data: Interview Details

Six members of the IPCT were individually interviewed between April and August 2012, allowing views about the challenges of the current process and potential for technology to be explored. One member of the IPCT interviewed for Study 1 was not asked questions relating to technology (Study 2) due to their specific role.

b) Recipients of Feedback: Interview Details

To explore perceptions of technology as a method to measure hand hygiene within the case study site five Modern Matrons, one Ward Manager and one Practice Development Nurse were interviewed between September and October 2012.

c) Subjects of Observation: Interview Details

Three Nurses, three Healthcare Support Workers and one Clinical Consultant were interviewed between August and October 2012. Technology was not discussed at the Link Nurses meeting, unlike the topic of the current measurement process, thus they did not participate in this study.

6.2.3. Summary of Interview Procedure

Interviews for this study explored measurement requirements which potential technologies would need to possess. Participant perceptions of both conducting auditing (GoD) and performing hand hygiene correctly (GoD, RoF, SoO) at specific moments of the audit tool used at the case study site (ICNA, 2004) were investigated. Participants were shown questions 32a-g (Table 6-4), which relate to the observation of hand hygiene practice, and asked their views on difficulty to execute. The GoD were asked two-tailed probes (see Interview Schedules 1,

[probe 6]; 3, 4 [probe 4], Appendix 3d). This reflected their position as individuals with experience both gathering data and performing hand hygiene to required standards.

Table 6-4: Frequency count for participant views on likelihood of missing hand hygiene at, and/or difficulty of executing hand hygiene/auditing, at specific ICNA points 32a-g

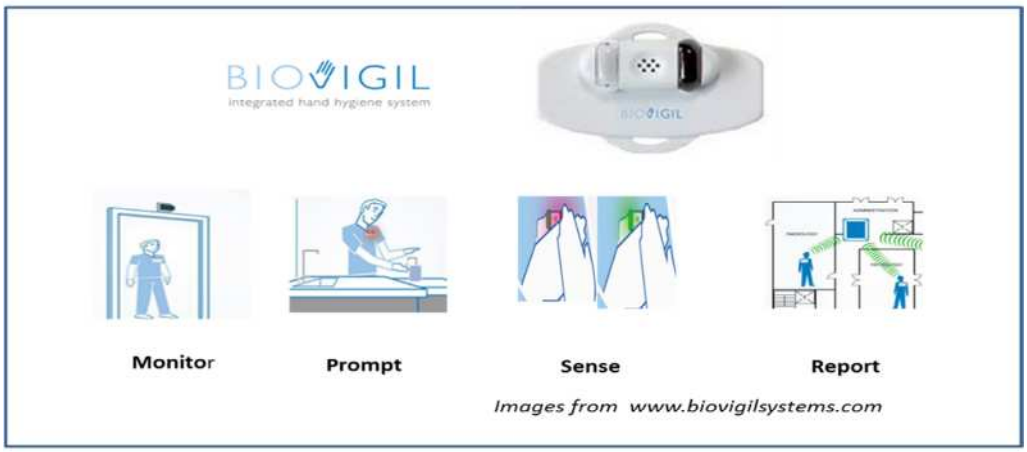
ICNA Point	**Agreed point liable to be missed, difficult to execute/audit**	**Disagreed point liable to be missed, difficult to execute/audit**
32a Following Patient Contact	3	1
32b After Removal of Gloves	4	0
32c Prior to Clinical Procedures	1	3
32d After a Clinical Procedure	0	3
32e Prior to Handling Food	2	1
32f After Handling Contaminated Items	0	2
32g After Leaving an Isolation Room	7	1

A similar exercise was carried out regarding the WHO 5 Moments. Participants were asked to consider their experiences and views as to the perceived ease or difficulty in achieving compliance (and/or auditing) for each of the WHO 5 Moments. As with the ICNA points, GoD were asked two-tailed probes, to reflect their duel knowledge bases, although it was acknowledged that currently they did not audit using a tool which explicitly looked for hand hygiene at the WHO 5 Moments. The instruction given was to consider *if* they were to be auditing, would they think that any of these Moments would be more difficult to audit (monitor, measure or provide feedback on).

Participants were also shown examples of current hand hygiene technologies, and asked for their reactions regarding potential to aid with hand hygiene measurement within their setting (Figure 6-1).

Participants were not informed that the objective of the second part of the interview was to discuss technology. This was to limit the possibility of influencing participant responses to probe 6/7 (Appendix 3d), which investigated views on "Ideal Scenario". The aim of this probe was to see whether participants voluntarily mentioned processes involving technology, or whether they had other views on how measurement may be achieved. The probe was included to help bridge the two sections of the interview, to allow the participant space to discuss ideas with the researcher, and allow the researcher to gain insight into the participant's current views towards measurement improvement.

For the GoD participants the laptop system was used to introduce technology examples, with a standard explanation delivered for each (Figure 6-1). Each technology was discussed, and any questions were answered. As with Study 1, paper-based visual tools were used for the RoF and SoO groups.



Typical description of system used with participants in Study 2
(based on information available from Biovigil within the public domain)

The first type of technology we are going to look at are badges. This particular one is by a company called Biovigil. Here you would wear a badge, and it would detect when you entered a particular area, it could be a Patient room, an isolation room, and it would show a red light. This is to provide a prompt that you need to perform hand hygiene in this particular area.
So, you would go and use the gel, or use the soap dispenser, and then you'd hold your clean hands up to the badge, and that would detect vapours from the decontamination agent, making the badge glow green. This then shows everybody that you have performed hand hygiene.
The system transfers this data to a central computer, so it also records that when you were in a specific area you were prompted to perform hand hygiene, and you responded. So it audits for you, and also provides real-time feedback.

Figure 6-1: Example of standard description used to describe technology examples. Participants were not shown description; this was presented verbally *(Appendix 2a for all examples)*

6.3. Analysis

Following a similar process to Study 1 (Figure 5-5) transcripts were analysed individually with codes being attributed to portions of text, related to defined categories (Table 6-5). Step 4 was not conducted, as will be discussed shortly.

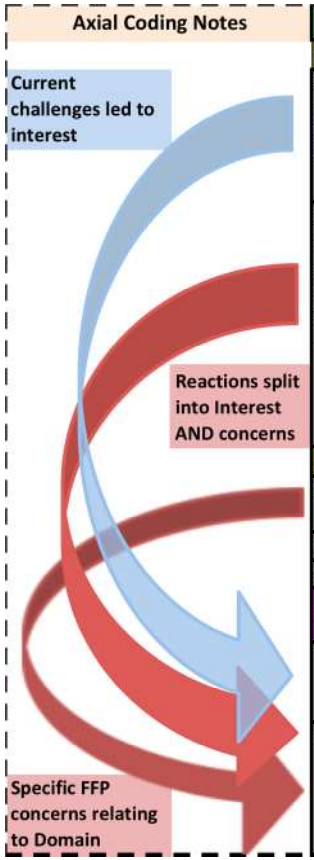
The two final interviews, an individual interview (from RoF group) and a group interview with three participants (from SoO group), provided no new themes. Thus thematic saturation was achieved after interviews with 20 participants.

Table 6-5: Coding schedule used in Study 2 to analyse interview data. Initial deductive and inductive themes produced from participant transcripts shown. Categories displayed were assigned to segments of text, using the listed abbreviated codes

Initial Theme	Category	Codes
Deductive		
S2/A2: **a:** Clarify if any of the Hand Hygiene Audit Observational questions (i.e. 32a-g) HP considered particularly difficult to monitor, measure, and comply with **b:** Clarify if HP consider any of the WHO 5 Moments particularly difficult to monitor, measure, provide feedback on, and comply with	ICNA Hard to Comply	ICNA Hard to Comply
	WHO 5 Moments Hard to Comply	WHO 5 Moments Hard to Comply
S2/A4: Reactions to Technology – do current Healthcare Professionals view existing innovations as useful for measurement/monitoring /feedback of compliance in their setting? **S2/A5:** Reactions to Technology – do current Healthcare Professionals view existing innovations as useful for measurement/monitoring /feedback of compliance with regard to WHO 5 Moments?	GoD reactions to Biovigil	GoD Bio
	GoD reactions to Sprixx	GoD Spr
	GoD reactions to Toronto	GoD Tor
	RoF reactions to Biovigil	RoF Bio
	RoF reactions to Sprixx	RoF Spr
	RoF reactions to Toronto	RoF Tor
	SoO reactions to Biovigil	SoO Bio
	SoO reactions to Sprixx	SoO Spr
	SoO reactions to Toronto	SoO Tor
Inductive		
Domain Specific examples (barriers to HH, feasibility of tech, general context)	RoF Domain Specific Examples	RoF Domain
	SoO Domain Specific Examples	SoO Domain
Inherent and Elective discussion - Unprompted	I/E Unprompted	I/E Unprompted
Social Nudging	Social Nudging	Social Nudging

The explicit nature of Aim 2 meant that no further inductive themes were required, the responses highlighted under each category allowed sufficient scope for investigation. For Aims 4 and 5 the reactions of the healthcare professionals were categorised according to the example presented, as each participant saw the same three technologies. However, during the data collection and analysis process it became clear that healthcare professional reactions fell within two broad spectrums: positive and negative. These reactions were labelled “Interest in potential” and “Concerns about technology”. Sub-divisions were made based on the content of the emergent data (Table 6-6). This replaced the Step 4 (Figure 5-5) conducted for Study 1.

Table 6-6: Exploration of emergent themes surrounding the reactions of healthcare professionals to the potential of hand hygiene technologies



Initial Theme	Category	Codes
Deductive		
S2/A2: **a:** Clarify if any of the Hand Hygiene Audit Observational questions (i.e. 32a-g) HP considered particularly difficult to monitor, measure, and comply with **b:** Clarify if HP consider any of the WHO 5 Moments particularly difficult to monitor, measure, provide feedback on, and comply with	ICNA Hard to Comply	ICNA Hard to Comply
	WHO 5 Moments Hard to Comply	WHO 5 Moments Hard to Comply
S2/A4: Reactions to Technology – do current Healthcare Professionals view existing innovations as useful for measurement/monitoring /feedback of compliance in their setting? **S2/A5:** Reactions to Technology – do current Healthcare Professionals view existing innovations as useful for measurement/monitoring /feedback of compliance with regard to WHO 5 Moments?	GoD reactions to Biovigil	GoD Bio
	GoD reactions to Sprixx	GoD Spr
	GoD reactions to Toronto	GoD Tor
	RoF reactions to Biovigil	RoF Bio
	RoF reactions to Sprixx	RoF Spr
	RoF reactions to Toronto	RoF Tor
	SoO reactions to Biovigil	SoO Bio
	SoO reactions to Sprixx	SoO Spr
	SoO reactions to Toronto	SoO Tor
Inductive		
Domain Specific examples (barriers to HH, feasibility of tech, general context)	RoF Domain Specific Examples	RoF Domain
	SoO Domain Specific Examples	SoO Domain
Inherent and Elective discussion - Unprompted	I/E Unprompted	I/E Unprompted
Social Nudging	Social Nudging	Social Nudging
Emergent Themes		
Technology - **Interested in Potential**	Aspects of design	AO Design
	Potential to aid hand hygiene measurement and compliance	HH Aid
	Training aid	HH Aid Training
Technology - **Concerns**	Fit For Purpose (Ability to detect context)	FFP - context
	Fit For Purpose (Ability to evaluate technique)	FFP - technique
	Fit For Purpose (Appropriateness of technology)	FFP - appropriate/environment
	Anonymity and Resistance	Anonymity/Resist
	Over-Reliance on Technology/Habituation	Reliance/Habit

Axial coding allowed links between current measurement challenges and "Interest in potential" to be established, whilst inductive categories raised by participants (e.g. barriers within specific wards) gave further context to "Concerns about technology" (Table 6-6). A frequency table assessing the level of these emergent themes was constructed (Table 6-7).

Table 6-7: Frequency count of data points relating to each of the emergent themes, and remaining inductive themes.

(Pp = Participants; GoD = Generators of Data; RoF = Recipients of Feedback; Subjects of Observation)

			Technology Discussed in Data Point						Data Points Contributed		
	Data Points		Pp	Badge	Dispenser	Surveillance	All 3 examples	Technology in General (not referring to examples shown)	GoD	RoF	SoO
Technology - Interested in Potential	Aspects of Design	15	10	10	0	5	0	0	6	4	5
	HH Aid	6	5	3	0	3	0	0	0	5	1
	HH Aid Training	6	6	2	0	3	0	1	1	2	3
Technology - Concerns	FFP Context	23	12	14	2	5	2	0	13	6	4
	FFP Technique	5	5	5	0	0	0	0	0	2	3
	FFP Appropriateness	29	13	4	22	3	0	0	10	15	4
	Anonymity Resist	26	15	8	4	7	1	6	6	11	9
	Reliance Habit	6	5	1	0	4	0	1	0	6	0

This analysis allows for a structured discussion in two parts, addressing requirements for technological measurement and reactions to technology.

6.4. Discussion of Results: Part A and Part B

The results from the structured literature review and thematic analysis of qualitative interview data allowed all five study aims to be achieved (Table 6-8).

Table 6-8: Study 2 aims displayed with corresponding methods for data generation and participant groups involved (*IN = Interview*)

Study 2 Aim	**Lit Rev /Data**	**GoD**	**RoF**	**SoO**
Aim 1: Determine whether any current technologies available measure/monitor hand hygiene at the WHO 5 Moments	✓			
Aim 2a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with Aim 2b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with		IN	IN	IN
Aim 3: Using existing case study site hand hygiene audit data identify potential areas where compliance appears particularly a problem Does this relate to healthcare professional perceptions (Aim 2)? Is there potential for technology to develop a solution?	✓			
Aim 4: Reactions to Technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring /feedback of compliance in their setting?		IN	IN	IN

Aim 5: Reactions to Technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring /feedback of compliance with regard to WHO 5 Moments?		IN	IN	IN

To develop the discussion regarding participant's views on the potential for technology to aid measurement of hand hygiene, themes from the interviews were split into two sections:

Part A: Themes relating to establishing what would be required from hand hygiene technologies (requirements for technological measurement).

This related to the first three aims of Study 2, and reflected the finding that no technologies were found which could detect all the WHO 5 Moments. The aim was to identify if any specific areas of auditing or performing of hand hygiene were perceived to be particularly difficult or easy. Findings from this can then inform technology design.

Part B: Themes stemming from the technology examples (reactions to technology).

This related to the final two aims, and explored issues of Fit For Purpose of technology and the importance of domain knowledge in performing hand hygiene.

Part A: Requirements for Technological Measurement

To assess the potential for technology to aid measurement at the case study site three specific areas were initially explored relating to (i) current measurement requirements as outlined by the ICNA (2004) tool (ii) measurement requirements relating to the WHO 5 Moments, known to be a priority of hand hygiene training (see 5.4.), and (iii) existing indications of weak compliance at specific points of measurement at the case study site.

a) Current Measurement Requirements (ICNA, 2004)

All participants were presented with questions 32a-g (Table 6-4), and asked their views on difficulty to execute. They did not have to give an opinion to all, or any, of the points. Views only needed to be given if they felt any of these ICNA points were more/less difficult to perform hand hygiene or audit hand hygiene at correctly. Of the 15 interviews (involving 20 participants) featuring the probe, 13 (involving 18 participants) resulted in offered opinions as to difficulty.

Findings were mixed. Different opinions were voiced regarding which points may be most likely/unlikely to be missed, or which were perceived to be/not be difficult to execute or audit, indicating a degree of personal difference within the topic of hand hygiene. The area of most agreement was that relating to the difficulty in correctly performing hand hygiene *After Leaving an Isolation Room* (32g), or being able to audit this point correctly.

This finding is supported by one of the GoD: *I do think the staff have problems, sometimes after leaving an isolation room, um, that's our lower level of compliance.*

Participant quotes add context to why the seven participants (2 GoD/4 RoF/1 SoO) nominated this point:

> *I mean, when it says* "After Leaving an Isolation Room"*, that could actually be a little bit confusing, because they wash their hands before they leave the room, in the sink that is in the room… I'm not so sure that everybody then would go and wash their hands again, outside of the room… if that was the case…then the sinks are at bed spaces, so you'd be going to another Patient's bed space to wash your hands…* (RoF a)

This participant came from a setting whereby all sinks are co-located in Patient Zones, allowing a unit 1:1 bed: sink ratio, yet prohibiting additional ad-hoc washing without entering another bed space. However, environmental barriers to hand hygiene (as discussed by Ducel, 2002 and Department of Health, 2003, see 1.3.) were also cited in other, non-1:1bed: sink settings:

> *But yes, the score is right, because technically no hand hygiene has been performed on leaving the Isolation Room, but it is a hard one, because the sink is literally the other side of the door, but when the staff member comes out they'd have to travel to find another sink, and often they're off to do something important, so they don't want to risk being distracted…* (RoF b)

> *Because we don't have the sort of isolation space between the actual Patient care room and sort of the outside world, so to speak…* (RoF c)

However, not all lapses were perceived to be due to environmental barriers, as identified by a healthcare professional based on a different ward:

> *…when I've done this audit myself on the ward you tend to find it's the multi-disciplinary team that come on, like Doctors, Physios, that aren't as clued up as ward staff – like you'll get them coming in and out of barrier rooms, and they'll not wash their hands...*(SoO)

Here the indication from the participant refers to the impact of hierarchy as a cause of poor hand hygiene at this point, in agreement with evidence for the

impact of role models. Suchitra and Lakshmi Devi (2007) surmised that knowledge that senior staff were non-compliant with hand hygiene standards led to it being natural that new recruits did not feel it important to comply with such requirements. Erasmus et al. (2010) also support the influence of role models, based on specified role (e.g. nurse, doctor) rather than hierarchical position alone. Leaving isolation rooms was, however, the only ICNA point where role model influence was raised as a contributory factor to poor hand hygiene performance.

It is important to note that this categorisation (Table 6-4) can only be considered a guide, to indicate areas perceived to be particular weaknesses or potential areas where measurement of hand hygiene behaviour may be of specific importance. Previously discussed flaws in individual interpretation of the ICNA points could also have led to a lack of clarity in the views contributed here (e.g. on 32a Patient Contact, 32c Prior to Clinical Procedures). Similarly due to the participants' diverse roles it is worth noting that some SoO and RoF groups also discussed views on the ICNA points from the aspect of ease/difficulty of auditing, as they carried out ward based audits in the capacity of Ward Managers, Modern Matrons or Link Nurses. A distinction between ease/difficulty for auditing and ease/difficulty for performing hand hygiene was not carried out, as the numbers falling into each category would have been too small for meaningful comparison. However as the information gathered was qualitative in nature, context was available to determine whether the conversation related to auditing or performing hand hygiene.

b) WHO 5 Moments

As with the ICNA points, participants only needed to offer views if they felt that one or more of the Moments were more/less difficult to perform hand hygiene or audit hand hygiene at correctly. All 15 interviews featured the probe, and all resulted in discussions regarding the ease/difficulty (Table 6-9).

Table 6-9: Frequency count for participant views on likelihood of missing hand hygiene at, and/or difficulty of executing hand hygiene/auditing at WHO 5 Moments

WHO 5 Moments	**Agreed point liable to be missed, difficult to execute/audit**	**Disagreed point liable to be missed, difficult to execute/audit**
M1: Before Touching a Patient	5	1
M2: Before Clean/Aseptic Procedure	0	4
M3: After Body Fluid exposure risk	2	4
M4: After Touching a Patient	6	2
M5: After Touching Patient surroundings	14	0

Findings were clearer than that for the ICNA points. The majority of participants (*N*=14) cited Moment 5 as the point most likely to be missed, or most difficult to perform or audit hand hygiene at. This is in line with recent findings from an observational study of rehabilitative therapists (Rossini et al., 2013).Rossini et al. (2013) found the lowest levels of compliance for Moment 5 compared with the other four WHO Moments (22.5% compared with M1 =36.5%, M2 =54.5%, M3 =25.2% and M4 = 25.4%). This lower level of compliance for Moment 5 was also found by Grayson et al. (2011) as part of their review of outcomes from the initial two years of the Australian National Hand Hygiene Initiative.

Contextual comments from participants may provide detail as to why Moment 5 regularly appears to be the lowest performing Moment in terms of hand hygiene compliance, despite evidence suggesting it provides the highest source of hand hygiene opportunities (Steed et al., 2011, Figure 6-2).

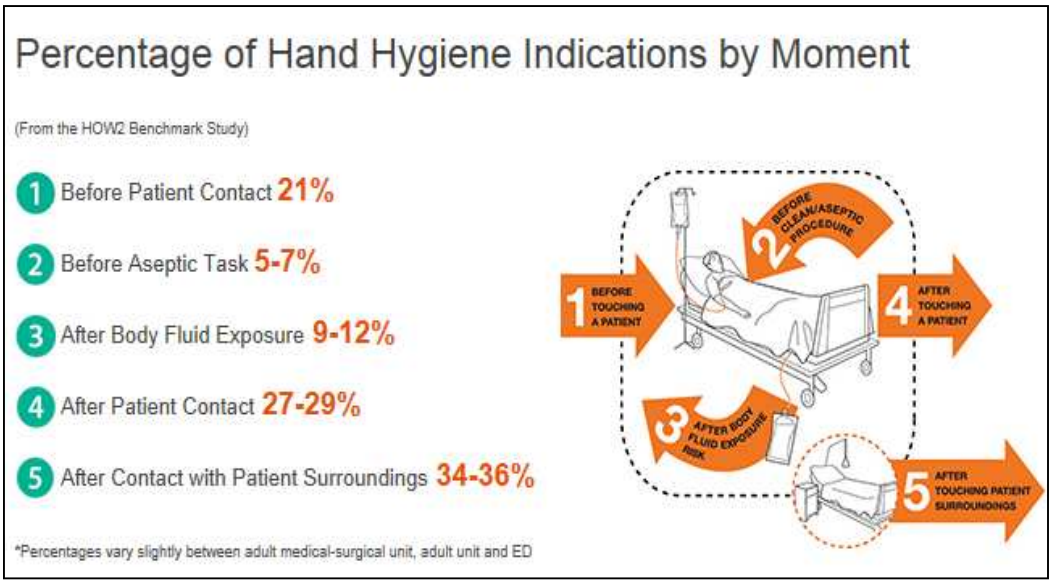


Figure 6-2: Data from Steed et al. (2011) obtained through direct observation within three acute settings, indicating the highest percentage of opportunities for Hand Hygiene at Moment 5[13]

Firstly, a lack of understanding of potential contamination risk via the Chain of Infection appeared to be perceived:

> *Well I think it's just, people don't necessarily see it as – when you see you touching the Patient, or you're doing something to a person… Just by touching an environment, i.e. it's not as serious… It is as serious – but do people perceive it as such?* (SoOa)

> *It's ignoring the concept of the Patient's potentially infected environment.* (GoD)

[13] Figure reproduced from DebMed (2013), location: http://events.debgroup.com/5-moments-of-hand-hygiene?utm_campaign=who-may-5th-clean-your-hands-day-campaign

Type of activity (investigated more in Chapter 7) was also volunteered as an indicator for whether hand hygiene would be performed or not, with the need for prompts, and possible explanations for non-compliance, suggested:

> *But on an ad-hoc basis, if they're just making a bed or something like that, I've noticed that people don't tend to gel their hands between doing beds and things like that, and you have to prompt people…* (RoF a)

> *…after they've touched, like, their* [Patient's] *locker, or their* [Patient's] *stuff, they don't think they need to. Because they think* "well I haven't touched anything that's contaminated". (RoF b)

The problem with obtaining compliance for Moment 5 was perhaps most succulently summed up by one of the GoD, who stated that:

> *People don't get the environment. Just don't get it. At all.*

Interestingly, in discussion of how workload may affect hand hygiene, known to have a negative effect on compliance rates (Pittet et al., 1999), Moment 5 was seen as being the one that could be dropped when under pressure. For example:

> *Mmm. When you're busy, that would be the last…* (SoO b)
> >>*Yeah.* (SoO c)
> >>*…that would be the one I would probably drop.* (SoO b)
> >> [Researcher: ...*when you're busy, Number 5 is the one that you think would get dropped…?*]
> >>*Yeah.* (SoO c)

This attitude, whereby it is deemed acceptable not to perform hand hygiene at some opportunities, links to the "Hierarchy of Risk" discussed by Whitby et al. (2006) in the formation of their Inherent and Elective theory of hand hygiene. Here, nurses involved in a focus group study described scenarios whereby hand hygiene would not always be considered necessary, focussing chiefly around the

concept of dirtiness. Activities which did not trigger such a concept included interaction with inanimate Patient objects which correlates with the definition of objects within the Patient zone, such as Patient bed, locker, table, curtain etc.

The suggestion, that different activities may lead to different levels of hand hygiene compliance, based on an underlying behavioural motivation, is the topic of Study 3, and as such is discussed more thoroughly there (Chapter 7). However, it is interesting to note that in terms of Moments being easy to audit or perform, discussions indicated that Moments 2 and 3 were perceived as being least likely to miss (Table 6-9). Indeed, of the two participants volunteering views about difficulty regarding Moment 3, one was referring to the audit process, rather than any difficulty in performing hand hygiene at this moment of Patient care:

> *The body fluid one, probably* [Moment 3]*….because you've got to follow somebody around…You know, they're taking something to the sluice room; you've literally got to follow them... …make sure they take their gloves off and wash their hands.* (GoD)
>
> >> [Researcher: *And then you've got the idea that they know that you're following them, so they're going to do it properly…?*]
>
> >>*Yeah.* (GoD)

The other participant volunteering Moment 3 tapped into a much wider issue, the emergent theme of glove use:

> *…the trouble is, with anything where the nurses are putting on gloves, half of the time they're taking the gloves off and not washing their hands, so I think there – number 3 – would get the, would get missed the most, as opposed to washing or gelling*. (GoD)

The overuse or inappropriate use of gloves, is discussed later (see 8.6.), however *After Removal of Gloves* did rate second highest on the *Agreed point liable to be*

missed, difficult to execute/audit category for ICNA points, based on participant comments (Table 6-4). Potential reasons for this, proposed by participants and literature, include glove use providing a *false sense of security*, and healthcare professionals believing glove use results in no need for hand hygiene (Fuller et al., 2011). In relation to glove use at Moment 3, this may hinder or block instinctive desires to perform hand hygiene driven by a feeling that hands are unclean, having physically soiled hands, or emotional motivators of disgust and self-protection (Whitby et al, 2006). Thus, where gloves are used for Moment 3, compliance may indeed be seen as lower, or missed, as discussed here by the GoD participant.

The remaining participants citing Moment 3, and those citing Moment 2, all did so in a way that suggested that these Moments would be ones they would consider unlikely to be missed. Unlike Moment 5 they were doubtful that they would be dropped regardless of workload considerations and participants perceived them as being understood well:

> *2/3 are routine, they are always done.* (RoF)

> *They get after blood and body fluids, er, they get before an aseptic technique…* (GoD)

Again, type of activity appeared to be perceived as a motivator for predicting that hand hygiene would be more likely at Moments 2 and 3. This was both in terms of activities being classed as inherently dirty (Whitby et al., 2006, 2007), and also the way an activity was perceived within set guidelines:

> …*Before* [Aseptic] *Procedures and After Body Fluids – people do wash their hands, because they see them as being dirty and they see that they need to have clean hands for a procedure because it's part of the guidelines.* (RoF)

Here the implication was that some clinical activities appear to be integrated with the need for hand hygiene, due to the explicit inclusion of it (hand hygiene) in written guidelines and procedures.

Interestingly Moments 2 and 3 link closely to those ICNA (2004) points rated least likely to be missed in, namely 32c *Prior to Clinical Procedures*, 32d *After a Clinical Procedure* (both highlighted by three participants) and 32f *Handling Contaminated Items* (highlighted by two participants). Whilst there is no direct correlation between ICNA (2004) points and WHO 5 Moments, as discussed in Study 1 outcomes, the wording on these five criterion (32c, 32d, 32f, Moment 2, Moment 3) are similar, and pointed out by a participant:

> ….*whoever was assessing that* [pointing to visual tool showing ICNA 32a-g], *would know those* [pointing to visual tool showing 5 Moment]… *And they would know that that's what that correlates to* [pointing to both visual tools, ICNA/5 Moments]… (RoF)

Therefore, when examining the impact of behavioural theory (i.e. Inherent/Elective hand hygiene) perhaps both Moments 2 and 3 *and* these three specific ICNA points could be considered.

In summary, the findings examining the WHO 5 Moments (Aim 2b) were more striking those examining the ICNA measurement requirements (Aim 2a). A consensus emerged from participants that Moment 5 would be the WHO 5 Moment they would consider most likely to be difficult to perform correct hand hygiene at, or audit correctly. Lack of understanding and lower priority given to hand decontamination were potential reasons. This was despite Moment 5 being reported as providing the majority of hand hygiene opportunities. These findings were considered when assessing the types of technology, to determine the level of potential as an aid for measurement.

c) Current Data Trends for Compliance

Aim 2a and Aim 2b examined whether healthcare professionals at the case study site perceived any of the ICNA (2004) audit points 32a-g (Table 6-4) or WHO 5 Moments (Table 6-9) to be more difficult to comply with or audit than the others. Aim 2a provided mixed findings, with a suggestion that point 32g *After Leaving an Isolation Room* may be the most challenging to meet the required standard at. Environmental barriers provided an explanatory factor for this. Aim 2b provided clearer findings, suggesting Moment 5 of the WHO 5 Moments was perceived as the most difficult to achieve, although auditing was discussed as being hard to discretely achieve for Moments 2 and 3 due to Patient confidentiality.

Issues with data accuracy limit the level to which the existing audit data held at the case study site can be used with confidence. However availability of four years' worth of data allowed the opportunity to triangulate the ICNA (2004) points perceived as more difficult to perform or audit (Table 6-4), with recorded data trends. Data was available from March 2009 to June 2012, although this did not represent a consistent flow of data during the period (Figure 6-3).

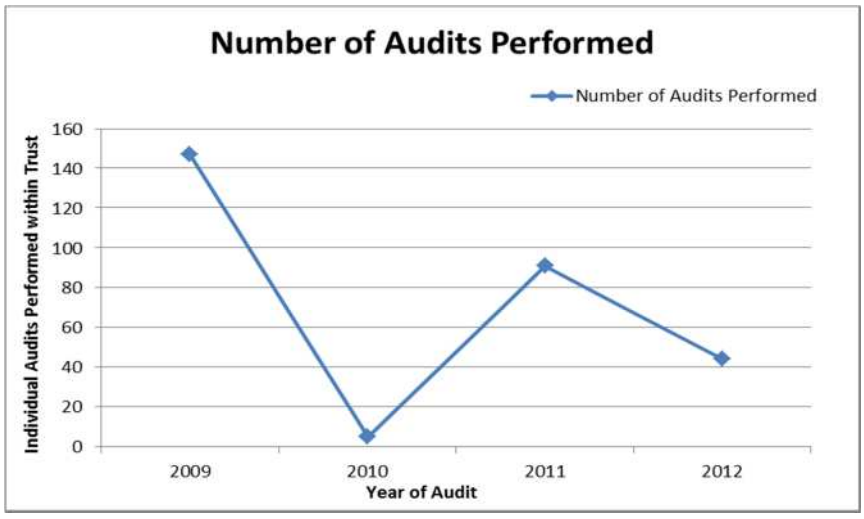


Figure 6-3: Pattern of Hand Hygiene audits performed at case study site from 2009 - 2012, demonstrating marked fluctuation

The data for the specific ICNA (2004) points regarding hand hygiene compliance discussed with the participants (i.e. 32a-g) was extracted for each of the audits. Data for both compliance rates (Yes/No) and whether an audit had been possible (N/A) at each ICNA point was examined.

The total number of *Yes*, *No*, and *N/A* responses to each of the seven ICNA (2004) points for all of the 287 audits on record were calculated to identify trends in compliance or lack of audit completion (Table 6-7).

Table 6-10: Number of *Yes*, *No* and *N/A* observations for each of the ICNA (2004) points, and accumulated compliance rate

ICNA (2004) Point:	**32a** Following Patient Contact	**32b** After Removal of Gloves	**32c** Prior to Clinical Procedures	**32d** After a Clinical Procedure	**32e** Prior to Handling Food	**32f** After Handling Contaminated Items	**32g** After Leaving an Isolation Room
No. Yes Observations:	196	150	55	79	32	95	85
No. No Observations:	43	28	24	23	6	30	20
No. N/A Observations	48	109	208	187	249	164	184
Accumulated Compliance Rate (%)	82	83	70	79	84	77	83

(NB: Yes indicates required hand hygiene observed, No indicates required hand hygiene not observed and N/A indicates audit was incomplete on specific point. Accumulated compliance calculation = Number of Yes observations/(number of audits on record – N/A observation rate)

Comparison of data points by compliance is difficult. The denominator, calculated by deducting the number of *N/A* scores from the total number of audits carried out, varies widely. Therefore occurrences of *Yes* or *No* may have a different level of impact on percentage score. The lower the denominator, due to high levels of

N/A, the greater individual instances of non/compliance will affect the overall percentage.

However, the findings from the current data suggest 32c *Prior to Clinical Procedures* has the lowest level of compliance, and also proves difficult to audit, with only 81 observations being successfully carried out across the 287 audits on record. Such a finding agrees with those of Grayson et al. (2011), who assessed hand hygiene compliance at each of the 5 Moments. With *Prior to Clinical Procedures* taken to be similar or covered by Moment 1 *Before Touching a Patient*, their results prove interesting reading, with Grayson et al. (2011) showing the second lowest level of compliance for this Moment (after Moment 5). On a similar note, in their systematic review Erasmus et al. (2010) found 35 studies which reported compliance rates both before and after Patient contact. A median compliance rate of 21% was found for *Before* Patient contact as opposed to a much higher median of 47% found for *After* Patient contact.

The findings of Rossini et al. (2013) differ, with their study reporting the second highest level of compliance for Moment 1 (after Moment 2). Contextual factors, due to the specific study setting (using therapists; respiratory and physiotherapy) may account for this difference in finding, whereby healthcare professionals may have a different work pattern than in general clinical care, where the data of Grayson et al. (2011) and the current case study was sought. Whilst therapists were not explicitly mentioned by Erasmus et al. (2010) their review did find an effect of healthcare professional role, with both *Before* and *After* compliance rates differing depending on role category (e.g. nurses with higher compliance than

physicians). Thus the differing results from Rossini et al. (2013) may represent, in part, the influence of setting and role upon hand hygiene behaviour.

The findings from the case study site data, that lower compliance was found for *Prior to Clinical Procedures* is in some opposition to the perceptions gathered from the participants. They rated this point higher on the "disagreed point liable to be missed, difficult to execute/audit" interview probe (Table 6-4). In other words, they perceived that hand hygiene *Prior to Clinical Procedures* would either be likely to be performed or non-problematic to audit. Similarly, compliance for point 32f *After Handling Contaminated Items* is surprisingly low, at 77%, when considering the reactions of healthcare professionals when asked about expected performance. None rated this point as liable to missed/hard to audit, and two highlighted it as a point they disagreed would be liable to be missed/hard to audit. Moreover, this activity can be seen to have links to WHO Moment 3 (*After Body Fluid Exposure Risk*), which was rated highly on the "disagreed point liable to be missed, difficult to execute/audit scale".

This discrepancy, between believed/perceived hand hygiene behaviour and measured hand hygiene behaviour directly correlates with the limitations of self-reporting (see 2.6.4.a), whereby self-reported rates of hand hygiene are often found to be over-reported in comparison to rates obtained through parallel direct observation (Tibballs, 1996; Larson et al., 2004). Similarly, studies using the Theory of Planned Behaviour (TPB) highlighted discrepancies between people's intended hand hygiene behaviour, and their actual physical behaviours. Thus the perceptions from healthcare professionals regarding hand hygiene rates they would expect at the different ICNA points may not relate to the measured

behaviours. Contextual issues such as time, ward intensity and healthcare professional role may all have a bearing on performed hand hygiene rates (see 2.6.2.).

The discrepancy between measured hand hygiene and perceptions held does not, however, invalidate the data gathered from the participants. Existing weaknesses with the standardisation of the process (see 5.4.4.) result in caution being required when interpreting collected data, especially considering the lack of clarity surrounding a definition of *Clinical Procedures* (see 5.4.3.b. ii). All data points, with the exception of 32a *Following Patient Contact* showed high levels of *N/A* in the data. All except 32b *After Removal of Gloves* could not be recorded on more than 50% of the 287 audits performed. The inference for technology may be that a system offering the ability to consistently collect data, making a greater amount available for analysis, may be of benefit to contribute to more meaningful percentage levels for further investigation.

d) Requirements for technological Measurement: Summary

Interview findings, combined with the analysis of existing audit data, revealed specific areas of Patient care perceived to cause problems when measuring or obtaining hand hygiene compliance. A marked contrast was found between healthcare professional perceptions of hand hygiene behaviour and trends in recorded data.

What is apparent from both sources, and the understanding of the current measurement process gathered from Study 1 interviews and participatory observation sessions, is that any technological intervention is unlikely to be able

to singularly cope with the complexity of required measurement. Thus systems promoted as a "silver bullet" to replace traditional compliance monitoring, such as Hill-Rom's Handwashing Compliance Solution which claims it *eliminates manual monitoring for hand-hygiene compliance* (Hill-Rom, 2010) would be unlikely to perform well at the case study site.

Issues such as environmental barriers and lack of clarity with regard to target behaviours (see 5.4.3.b.ii) may exacerbate the challenge posed to integrating technological solutions into hand hygiene compliance monitoring. Exploring the perceptions of those involved allows the gathering of views on the potential areas technology may be able to assist. Therefore examples of current technologies were used to gather reactions from participants, to investigate their Fit For Purpose in relation to the case study site.

Part B: Reactions to Technology: views on Fit For Purpose of Current Technologies for the Case Study site

All participants were shown examples of current technologies available for hand hygiene compliance monitoring, drawn from a selection generated through an initial literature review.

Participants offered their views on the three different technology examples, with strengths and weaknesses of each system providing the main topic of discussion. The objective here was not to provide a critique of the specific systems, more to present the over-riding perceptions of the healthcare professionals on the topic of the potential for technology.

Analysis of results identified two main themes relating to the examples given, namely (i) interest in potential, and (ii) concern over technology.

a) Interest in Potential

Participants from all three API groups provided views, categorised as *Interested in Potential,* offering opinions of the technology examples. 11 of the 20 participants provided examples of their interest. Aspects of design and potential to aid hand hygiene measurement and compliance were the main discussion topics generated.

i. Aspects of Design

Of the three examples shown (Appendix 2a) the healthcare professional badge system received the most enthusiastic response, predominantly based on its use of a visual display providing real-time feedback to peers and Patients (Table 6-11).

Table 6-11: Examples of positive feedback from participants regarding design of healthcare professional badge system

Participant Quotes
I quite like the light, cos that's visible…and people can, you know, Patients can see that, other staff members can see it, everybody……walking onto the ward can see whether you've got a red light or a green light…and I'm quite liking that idea…I think colour's quite good. If you walk onto a ward and everyone's red! (GoD a)
*..a flashing of a light, I mean I can't see that it would cause any harm, if anything if it reminds somebody, that can only do some good really, I would have thought… (*RoF a)
I like the fact that it's visual. To more than just the person wearing it, because from an 'involving the Patient's in their care' perspective, which is really important, because, you know, there's no stronger message than a Patient saying 'I haven't seen you washing your hands'. *Um, it takes somebody brave to*

say it. (RoF b)
I like the idea of it…because at least you can see people walking around, who's washed their hands and who hasn't…Who's done it. (SoO)

The healthcare professional surveillance system example also provoked positive responses, predominantly relating to its all-encompassing capability: *That's very good. You wouldn't miss as many opportunities then. Would you?* (RoF b)

The importance of design for acceptability within hand hygiene technology was highlighted by Boscart et al. (2008), the team responsible for the healthcare professional surveillance system technology example. During the development of their system, which incorporated a worn dispenser with monitoring and prompting features, the views of healthcare professionals were formally elicited. These views, collected during two phases of study, were used to develop further modifications of the prototype.

Similar to the findings here (Table 6-11), feedback from the healthcare professionals in the Boscart et al. (2008) study was positive regarding the visibility of the device. Whilst the prototype device was not explicitly using a visual prompt (e.g. a light), the very nature of wearing it was felt to be giving a visual indicator as to the individual undertaking hand hygiene auditing. In particular the participants reported that even being seen to be wearing the device may *demonstrate their professional accountability, i.e. that they were 'paying attention' to hand hygiene* (pp. 219). This echoes the response from one of the GoD with regard to the use of technology in general, who enthusiastically replied: *If you get any like, gadgety things that you want us to trial we will…It shows that we're working towards something then.*

In line with Boscart et al. (2008), the discussions regarding the specific use of the system at the case study site revealed more critical insight in addition to positive views.

Critically, in terms of the purpose of hand hygiene technology, discussions focused not only on design preference, but also on the potential of the examples to improve hand hygiene compliance. This was through provision of more accurate measurement systems, or through the presence of real-time feedback (prompting).

ii. Potential to aid Hand Hygiene Measurement and Compliance

Technology examples elicited views regarding their potential to aid hand hygiene, and the associated challenge of accurate measurement. A key theme within these discussions was the potential for such technologies to prompt behaviour, through the use of real-time feedback, in addition to their function as measurement tools.

The use of electronic systems to provide prompts has previously been shown to increase hand hygiene compliance. Swoboda et al. (2004) used electronic voice messages to prompt healthcare professionals to perform hand hygiene upon room exit, if they had failed to perform decontamination independently. Their study, based within an intermediate care unit, also featured a visual prompt during the night shift (10pm – 6am) in replacement of the audible prompt. Data collected from electronic monitoring during two six month and one three month phases (between July 2000 and October 2001) revealed a positive effect of an increase in mean compliance upon room exit from 19.1% (no voice prompts) to 27.3% (voice prompts). This positive effect appeared sustained even when voice prompts were removed in a subsequent phase. Compliance fell only slightly to 24.3%. The

authors conclude, by combining data from both follow-up phases, that the use of voice prompts led to an overall increase in hand hygiene compliance at room exit of 44%. Whilst acknowledging weaknesses with the electronic monitoring system may affect the study validity, (it was not 100% accurate at detecting personnel exiting a room) the indications for an improvement in hand hygiene through the use of prompts, here in electronic format, are persuasive. Furthermore, their evidence is not isolated. Additional support for the use of electronic prompts comes from Venkatesh et al. (2008), who based their study within a haematology unit setting.

A two-phase study using ABHR dispensers fitted with electronic counters compared baseline hand hygiene compliance at room entry and exit with rates generated through the use of prompts. Here the prompts featured both visual (flashing lights) and audible (beeps and voice) components. The authors found an increase in hand hygiene compliance between phases, with the initial baseline figure of 36.3% being more than doubled to 70.1% in the intervention phase (prompts used). Again, the study has limitations, predominantly in this case the duration of the phases, which were short and, in the words of the authors, sporadic. However the significant increase in compliance rates is in keeping with Swoboda et al. (2004) and promising.

Participants showed positive views on the prompting potential of technology for hand hygiene (Table 6-12), mirroring the findings of Boscart et al. (2008) who also elicited the views of healthcare professionals. In their study participants offered views on how prompting may or may not work within the specific care environment, leading to implications regarding challenges of identifying the

Patient Zone, crucial for any attempt at integrating the WHO 5 Moments. Similar issues were raised by participants with regard to Fit For Purpose of the technologies.

Table 6-12: Examples of positive feedback from participants regarding prompting from technology examples

Participant Quotes
I suppose it's prompting people to do it….(SoO a)
That's one would be good. The personal one [healthcare professional badge system] – *because then when it goes red you know you've got to do your hands. That would be a prompt.* (SoO b)
I think that's good – how it prompts. Particularly for those areas where you don't always remember to do the hand hygiene…you might say it's a bit false, because it's prompting you, that's – we're here for the Patients… Not for who, or how well somebody's, um, remembering all the time to do something. It's more about making sure we're making the Patient safe. So if you have to prompt somebody every time, and they do it, then that's fine. (RoF)

A belief was voiced regarding the additional aspect of measurement being particularly useful to ensure that reminders were actually effective:

> *…cos it's alright saying* 'now wash your hands' *but it doesn't mean you're going to do it, but if it's detecting via the vapour...You can't get away with not doing it can you.* (SoO b)

This is in line with empirical work using the same healthcare professional badge system which received positive reviews from the participants (Table 6-11). Edmond et al. (2010) trialled the visual prompting system in an orthopaedic setting. In a comparison between two phases (four week baseline, two week intervention) measurements recorded by direct observation and those recorded using the technology showed significantly higher levels of compliance when the

badge system was in use: 66% to 93% respectively. The technology measured individual responses to prompts given and demonstrated changes in behaviour in a positive direction. Study limitations, like Swoboda et al. (2004) and Venkatesh et al. (2008) included duration of phases and use of single units for settings. However evidence supporting the notion expressed by participants, that prompting and recording of behaviour would lead to higher compliance, is encouraging.

Finally the potential to enhance training through providing specific feedback emerged as a theme (Table 6-13).

Table 6-13: Examples of interest from participants regarding training potential of technology examples

Participant Quotes
Um, I love the report (!). And, you know, the different levels of detail you could get from it – so you know, generally, or then honing down then on individuals that might need more training. (RoF a)
I'd be interested, to see where I could improve, definitely." (SoO)
"…as an initial thing it would raise the profile, and get over that cultural thing that I said, that unless it is seen as 'A Procedure', you know it's not necessarily seen as 'Patient Contact'. So that would address that issue wouldn't it? And it would address that issue that actually this is a moment of contact, this is a point of contact, um, you do need to be mindful that decontaminating your hands is actually relevant, and so it would get over that. (RoF b)
Erm…I think their behaviours should be accountable for, because something as washing your hands can actually save somebody's life, if you are washing your hands at the right moment, I don't think….I don't think that you have to, I don't, I wouldn't want to use anything like that to blame individual people, but to use it as, err, to educate people why it's important that they're not…I, I bet a lot of people wouldn't even realise that they haven't washed their hands at the right moment, they wouldn't, never hurt somebody on purpose, by not washing their hands at the right moment… (GoD)

For auditing to be successful, generated data has to be fed back effectively, possessing the quality of having meaning to recipients, therefore allowing them to take necessary actions for improvement (Larson et al.,2013;Hysong et al.,2006). Here the response from the participants highlighted the potential for technology to provide this required meaning. Whilst limitations in the technology prevent full information about performance at all 5 Moments being available, the opportunity for data about personal performance at Moments 1, 4 and 5 was embraced positively.

Cheng et al. (2011[14]) report on a badge system technology with capabilities to specifically measure WHO Moments 1 (*Before Touching a Patient*) and 4 (*After Touching a Patient*) using wireless technology, trialled in a six bed neurosurgical ICU in Hong Kong. The technology, commercially named "MedSense" compensates for the lack of human observers for measurement by using assumptions, with details for information flow given within the paper. For example, following observations and consultation with infection control personnel at the test site, a cut-off period of 15 seconds was used. Activity taking place within the Patient Zone with duration of less than 15 seconds was deemed unlikely to involve Patient contact, thus such events were not recorded by the system as hand hygiene opportunities. Event duration (time between entering and exiting the allocated Patient Zone) was also used to calculate workload intensity, allowing further analysis using the system to take place. This system, whilst

14 Due to the timing of the study publication this example was not available for inclusion for discussion with participants in Study 2, however themes covered by the technology (e.g. capability to measure at specific Moments) did emerge during the interview process.

currently only at a pilot stage, appears to offer early indications that technologies may allow specific feedback on individual performance at two of the WHO 5 Moments for hand hygiene. This data could then be used to provide meaning to inform future training and interventions, which is important for efficacy. Cheng et al. (2011) also demonstrated the potential of technologies to provide information on hand hygiene performance differences on a more organisational level, by providing data on the impact of workload, time of day and professional role. As the use of individual data can be contentious, such considerations of alternative use are of interest.

b) Concern over Technology

Analysis of the data from participants revealed three main emergent themes with regard to technology concerns. These were categorised as *Fit For Purpose*, *Anonymity and Resistance* and *Over-Reliance on Technology/Habituation*. Such themes were perceived by the participants as limitations of the technology examples which would make them have reservations about using them within their current clinical context. This view was held for both hand hygiene auditing and increasing compliance, which was seen as a parallel intention of the technology examples.

i. Fit For Purpose

The need for effective hand hygiene, by using appropriate agent, technique and timing to break the Chain of Infection is of clear relevance when evaluating technologies for measurement. The current gold standard for measurement, direct observation is preferred, in spite of its limitations, due to its ability to provide

context and details as to the hand hygiene event being monitored, including its effectiveness. The importance of such detail and meaning for feedback, and the Hysong et al. (2006) variables of individualisation and customisability was discussed and established in Study 1. To be Fit for Purpose technology innovations for hand hygiene measurement need to be able to aid healthcare professionals achieve specific targets in relation to monitoring, measuring and feedback. The comprehensive nature of these targets was ascertained by the researcher during participatory observation sessions in Study 1. This provided background to understanding the challenges faced by technologies in providing an alternative method of measurement. Within this sphere, participants identified their own topics of concern regarding the examples shown, namely *Ability to detect context*, *Ability to evaluate technique*, and *Appropriateness of technology*.

Ability to detect context

Participants expressed concern over the ability of technology to provide context on a par with the existing method of direct observation, specifically the limitations of sensitivity i.e. inability to pick up hand hygiene at the 5 Moments (Table 6-14).

Table 6-14: Examples of concern from participants regarding potential of technology examples to be context specific: when to wash hands

Participant Quotes
It's a start, but like what's saying as soon as they've washed their hands when they've come into that area that they're going to carry on using the '5 Moments' when they get to the Patient? (GoD a)
*How would it prompt you, you know, Before Patient Contact, After Patient Contact, how would it know…?" (*GoD b)
Yeah….but it's again, it's not picking up body fluids…(SoO)
What about learning or auditing once in the room? It only supports part of the picture, and it may be giving a false picture. (RoF)

A clear example of technologies failing to establish context can be seen in discussion of the weaknesses of those focused on door/room entry and exit. This applied to 12 of the 18 identified by the initial literature review (see 3.2.3.). Whilst recorded hand hygiene compliance rates may be pleasing, such as Edmond et al. (2010), they may not reflect effective hand hygiene in terms of performance at key times for reducing cross-transmission. As identified by one of the GoD (Table 6-14), performing hand hygiene upon entering an area is no guarantee that guidelines such as the 5 Moments are then going to be successfully followed. Thus by the time Patient contact actually occurs, hand surfaces may be contaminated with potentially dangerous pathogens (Creamer et al., 2010). Therefore, whilst 32g *After Leaving an Isolation Room* was perceived by participants as the current ICNA point most likely to lead to non-compliance, technologies which may increase adherence at this point may arguably not be of significant benefit to Patient safety.

Similarly, a main reason for non-compliance with hand hygiene has been cited as being irritation to skin (WHO, 2009), including over-drying leading to abrasions. To avoid such issues prudent hand hygiene is an increasingly important message within infection prevention (C. Kilpatrick, Healthcare Consultant, personal meeting, 23rd January 2013). This entails communicating not only when to wash hands, but also ensuring blanket hand hygiene is not encouraged i.e. explaining that hand hygiene when unnecessary is not beneficial. Participants volunteered views along this theme in response to the technology examples shown, expressing concern that such innovations may encourage unnecessary hand hygiene, predominantly when no contact, either with a Patient or surface, had occurred (

Table 6-15).

Table 6-15: Examples of concern from participants regarding potential of technology examples to be context specific: when not to wash hands

Participant Quotes
… it still has its flaws, doesn't it? Because I could come into the Patient Zone; "Hello Mrs Smith, would you like a cup of tea?*", and walk away – why would I need to wash my hands? And I've gone into that zone… what would that data tell? Why would I need to wash my hands – because I haven't touched the environment….?* (GoD a)
*My first gut reaction would be, well, it, you might not need to wash your hands when you're entering an area…Because we don't want people washing their hands unnecessarily, because you know they need, they could get sore skin…(*GoD b)
I think it could be giving the wrong information sometimes. Cos it, the sensor is not going to know that person has just gone in there to relay a piece of information to somebody. If they'd gone in there to care for a Patient and touched things, then that's slightly different, and I would expect nurses to wash their hands, but just maybe saying "there's somebody on the phone for you"… *(*RoF a)

In discussions of technology limitations Boscart et al. (2008) and Swoboda et al. (2004) both agree that false negative scores would be a major challenge for hand hygiene technologies. Innovations would require the nuance to detect whether hand hygiene would indeed be required by an individual entering a certain designated area. In the case of Boscart et al. (2008), healthcare professionals were consulted for views about a monitoring and feedback prototype technology. During this process the issue of false negative scores arose, as with the participants here in Study 2 (

Table 6-15). With Swoboda et al. (2004) the authors acknowledge that the data reported through systems lacking sensitivity to context will be affected by skewed denominators (hand hygiene opportunities). The presence of individuals who will not need to perform hand hygiene (and thus will legitimately probably not perform it) will erroneously be included in a denominator HHO figure. Their non-hand hygiene will appear as non-compliance, as the numerator will remain unchanged; a lower than factual measured compliance rate will ultimately result.

To counter issues such as false negative scores, participants suggested that they could document their own exceptions (e.g. entering a room to talk to a Patient and emergencies with Patients as reasons why hand hygiene may not be performed), thus being able to manually adjust denominator (HHO) scores (Table 6-16). However, concern was expressed as to whether this would be feasible, with issues of practicality and remembering highlighted. This bears strong parallels to the limitations of self-reporting of hand hygiene compliance, where validity of data has been shown to be poor. Furthermore, with immediate feedback devices, concern was raised that false messages would be being sent out to both peers and Patients, potentially causing needless anxiety (Table 6-16).

Table 6-16: Examples of concern from participants regarding potential of technology examples to be context specific: special circumstances

Participant Quotes
It's just another thing to do on your list of things to do at the end of the day that, you know, on your record it's gone down that 3 times you didn't gel your hands or wash your hands when you entered that area, but it could be that that Patient , erm, was confused, and you were helping, or stopping them falling, things like that… (RoF b)
What about your emergency situations? Cos you know, your first reaction isn't

to go and wash your hands when someone is on the floor is it?…It would still glow red? (SoO b)

Of note, in interviews and participatory observation sessions carried out for Study 1, participants confirmed that hand hygiene auditing would cease should an emergency occur on a ward during the observation period, due to known changes in healthcare professional priorities and behaviours:

> [Researcher: *When you've been doing an audit, have you had situations like that?...Do you go for an N/A, do you put comments on, or do you just leave the audit?*]
> *>>I think it's just best to say just leave it…you'd leave and go back. If there was something kicking off on a ward there's no use standing there with a clipboard.* (GoD)

Thus the prospect of future measurement methods (i.e. technology systems) not taking exceptional circumstances into account, and recording such non-compliances, may have appeared particularly alarming to the participants at the case study site.

Ability to evaluate technique

In addition to appropriateness of hand hygiene events, to measure effective hand hygiene technologies would need to be sensitive enough to determine whether decontamination met required standards. None of the technology examples shown were able to ensure hand hygiene technique was correct, a fact noted by participants discussing their potential for measurement (Table 6-17). These examples were representative of the 18 identifiable technologies reviewed, as none were capable of evaluating hand hygiene technique.

Table 6-17: Examples of concern from participants regarding potential of technology examples to be context specific: hand hygiene technique

Participant Quotes
Because that audit – if they just went like that [poor quality rub] *it would say that they'd done it, but they hadn't really done it…* (SoO)
I suppose the only thing it doesn't do is it doesn't actually check your technique does it? (RoF a)
How does it detect that…the, er, hand hygiene has been effective? Performed correctly, as opposed to, you know, the gel and that [mimes cursory hands rubbed together, not correct technique]. (RoF b)

The focus on frequency over technique is not a weakness limited to hand hygiene technology development (Erasmus et al., 2010; Haas and Larson, 2007). Gould et al. (2007b) found that only 8 of the 48 interventions included in their review evaluated hand hygiene technique. They further commented that these suffered from mixed methodological design and quality. Whilst hand hygiene technologies are currently being developed that have a focus on technique (SureWash, 2013) they have a more specific scope than the general acute setting, the focus of the case study research. Often they are applied as training tools, or in the case of SureWash, for the specialised surgical hand hygiene routine and setting.

Appropriateness of technology

Of the technology examples used the healthcare professional dispenser system (see Appendix 2a) received the most negative responses, predominantly due to its inability to provide meaningful data, although also stemming from the limitations of being ABHR based only (Table 6-18).

As with discussions of current methodology limitations using product usage (see 2.6.4.b), simple provision of numerical data cannot be considered a complete solution to the measurement of effective hand hygiene, as it does not provide details of appropriateness of decontamination agent, technique or in what context the hand hygiene behaviour occurred. Whilst mixed results from empirical studies show some correlations between direct observation and product usage (Boyce, 2011), indicating limited usefulness of the method as a tool for measurement, the lack of focus on effective hand hygiene cannot be ignored, especially when considering innovations designed to improve current measurement methods. Such considerations were not lost on the research participants (Table 6-18).

Table 6-18: Examples of concern from participants regarding potential of healthcare professional dispenser system

Participant Quotes
It'll be like a pedometer won't it? People'll just stand there and press it…? Two appropriate is better than a hundred standing emptying it into the sink. GoD (a)
The other person could have had a lot more person, er, Patient care…er, than the other one. It could have been an office day or something.(GoD b)
You may think it's good but then they may have been to a Patient 50 times and they've not, they've only recorded once, that they've… done it. And really, if you're missing so many you're then missing, er, sort of, you know, you might be affecting a Patient…You've only got to miss once. So it's great for providing data to show how, how many times it's used, it still doesn't show you whether that's as many as it should have been used.(RoF a)
We don't know the context in which they're working on any given day, how many Patients they're working with, what tasks they're doing – none of that detail would be available to you… (RoF b)

We've also got staff that don't use gel, they always wash their hands…And that's often Medical reasons, often. And that's a personal choice, because they feel they can decontaminate their hands better if they wash their hands. (RoF c)
...also, if I hadn't used it, and I knew they were going to be looking at the data, there's nothing to stop me just pressing it a few times randomly and fooling people… (RoF d)

The reactions of the participants to the concept of a technology which would measure and report their gel usage is represented by one GoD participant:

> [Researcher: *Do you think that's* [Healthcare Professional Personal Dispenser] *useful?*]
>
> *>>No, I don't. To be frank.* (GoD)

In defence of gel-dispenser based systems, current work by one company (DebMed, 2013) offers interesting reading, due to the inclusion of validated WHO 5 Moments data to underpin their measurement tool. Here, wall mounted dispensers (soap/foam/gel as desired) are designed to electronically monitor usage, and provide feedback in the form of standardised, easy to interpret reports. The example used in research interviews (Sprixx, 2008) reports only frequency and generated data could be deemed meaningless by lacking the ability to provide information on how to improve practice. Unlike this, and other similar products, the DebMed system uses an algorithm based on benchmark data generated by an empirical study (Steed et al., 2011).

This study, the "HOW2 Benchmark Study" collected data on hand hygiene compliance at each of the WHO 5 Moments within three clinical units (adult ICU, adult medical-surgical, emergency department) at two hospitals in the US. The authors detail specific calculations involved in the production of hand hygiene

opportunity estimations for each setting, based upon factors including Patient: Staff ratios, staffing levels, and unit type. Such a figure is designed to become a proxy measurement denominator, against which similar units could compare their own findings. This aims to allow institutions to compare whether current hand hygiene levels meet what would be expected according to the algorithm output (How2 denominator). Work is currently being done on broadening the scope of this innovation, for example determining the changes required for the algorithms to be of relevance and use for settings outside the US (including UK, Australia) (J. Hines, R & D Director, DebMed, personal meeting, 15th March 2013).

Finally, with regard to being Fit For Purpose, participants volunteered context-specific information to explain how the technology examples may not be able to withstand particular challenges within their environments. As the case study site is a large NHS acute Trust, with the participants representing multiple clinical areas (*N*=8), it is unsurprising that a one-size-fits-all design would be unsuitable. Participants offered views on cost, physical considerations and practicality of installation (Table 6-19).

Table 6-19: Examples of concern from participants regarding potential of technology examples to be context specific: Suitability for environment/role

Participant Quotes
Yeah. It's incredibly expensive I bet. (GoD a)
Anything that clips onto my pocket here (demonstrates) – gets in my way, and I really don't like it. Erm, even to the point where I slip my watch in my pocket. (RoF a)
*Probably be very good in somewhere like ITU. Like in areas where it's more 1-2-1. (*SoO)
The amount of Patient movement we have on this ward as well, because we can sometimes have 1 Patient in 3 different bed spaces and 3 different Patients in 1 different bed space, in 1 day… So it's going to be very difficult to track those moments in terms of what's appropriate at that bed space, for that Patient… (RoF b)
And the environment is very important in Midwifery, particularly in labour, because everything is, um, labour is enhanced by the hormones… (RoF a)

As already noted, the value of input from healthcare professionals has been recognised (Boscart et al., 2008).Research into the technology acceptance model (TAM; King and He, 2006), whilst outside of the scope of the discussion of this research, further supports the need for involvement of end-users (here the healthcare professionals) in the development of innovations to improve the likelihood of successful implementation and uptake.

ii. Anonymity and Resistance

The findings of Study 1 allowed for a discussion of meaningful feedback, leading to a proposed adaptation of Hysong et al. (2006)'s emergent model for actionable feedback. A key component of this model is the need for feedback to be non-punitive, to allow for a collaborative, supportive environment to emerge in which

improvement strategies can be developed. However, when assessing the concept of hand hygiene technologies, participants were highly concerned about how such innovations would be used, with the term *Big Brother* independently raised in all interviews (group and individual), and themes of results being used against staff emerging (Table 6-20).

Table 6-20: Examples of concern from participants regarding potential of technology examples to be punitive: issues of anonymity and resistance

Participant Quotes
And then there's what do you do? With that information. .. You know. How is that going to be used? Because some people will be quite paranoid about that, in terms of "oh, that's going to be used against me". (RoF a)
Depends how it would be used towards me… (SoO a)
What would happen if a Patient became septic or whatever…? They could… track me down… And make an example of me. (SoO b)
Or complaints. You know, family complaints – somebody has a terrible wound infection and unfortunately, they end up dying…Are the family going to be able to request all this information…? Once they go to legal to request all the records and things like that then …. It just has severe implications. (SoO a)
With anything like this it always makes me think that, you know, we are actually professional, and, I find it a little bit insulting really…(!)..you know, Big Brother watching over you… (RoF a)
It's like Big Brother, innit? (SoO c)
Yeah. I said that at the beginning, it's like Big Brother. (SoO d)
We're watching you (!) (GoD)

Issues with individual resistance to engaging with technology possessing monitoring capabilities have been reported with similar innovations introduced within the food sector. A report dating from the late 1990's (Anon, 1997)

highlighted the case of union members from an Atlantic City casino who felt moved to take legal action based on the notion that smart-badges which tracked hand hygiene of catering staff *violated worker privacy* (pp. 1).

Resistance was noted by participants in this study, with two RoF highlighting the difficulty of compliance and engagement with innovations:

> *...and you know, you've then got issues of: 1) Compliance with actually wearing it…* (RoF a)

> *I think, from a Staff Engagement point of view, they probably won't be overly favourable…Purely because of the monitoring approach, and how individualised it is… not necessarily because of my compliance with hand washing, but because it's going to monitor where I am, and where I am going…* (RoF b)

This viewpoint, with regard to negative staff engagement was confirmed during a subsequent interview with a SoO, who independently volunteered a response demonstrating strong negative feelings towards the concept of monitoring technology:

> *…I'd probably wear it for about a day and then chuck it in the bin. Um, I think it would make me think of Big Brother, and that a computer is controlling me from afar…*

Of note, prompting has been investigated for healthcare professional acceptance even without a technical aspect. Longtin et al. (2012) performed a survey of healthcare professionals with regard to their views on a hypothetical Patient participation programme to improve hand hygiene compliance at University Hospitals, Geneva, Switzerland. An anonymous survey sought views on the use of a badge system similar to that used elsewhere (the Cleanyourhands Campaign, England), which invited Patients to ask the healthcare professional wearer whether

hand hygiene had been performed. Despite finding that 74% of respondents believed that Patients could help prevent HCAI, 29% of respondents did not support the concept of being reminded to perform hand hygiene by Patients. Both the belief that it was not the role of the Patient to provide such a prompt (27%) and a refusal to wear such a badge (37%) were found to be barriers. As with the participants in the current study, respondents to the Longtin et al. (2012) survey also highlighted concerns about such a prompt system evoking feelings of blame or even legal issues:

> *Forty-four percent admitted to a feeling of guilt if patients discovered that they omitted hand hygiene, and 43% would be ashamed to disclose that they forgot to cleanse their hands. Forty-six percent feared that acknowledging omission could stir patient anger, and 26% believed that it would make them seem inept. Interestingly, 18% feared that admitting their omission to perform hand hygiene could lead to legal action.* (Longtin et al., 2012, pp. 1516)

Therefore, in terms of implications for technology developers these findings indicate that themes of anonymity and resistance, stemming from concerns of punitive action and a blurring of role boundaries, may not be isolated to innovations in their field. This may be endemic across the board where prompting techniques are involved.

iii. Over-reliance on Technology/Habituation

Finally the emergent topic of an over-reliance on technology and the related issue of habituation, discussed in terms of both clinical setting and changes in staff behaviour was found (Table 6-21).

Table 6-21: Examples of concern from participants regarding concerns of over-reliance on or habituation to technology

Participant Quotes
I wonder if you'd ever switch off from it… You know like with the monitors and the bells? Sometimes we become immune to it. We hear it but we don't hear it. (RoF a)
I suppose I worry about the taking away of initiative, from people, um, and I – as long as you have that [technology] *in your environment – but then what if one of my Healthcare staff went to an area… Like a number of the Nurses in here, you'd have to have it everywhere in your organisation – you couldn't just have it in one particular department, because you would have a reliance on technology… And if Nurses are, you know, if they're – they just might forget because they're used to a sort of trigger mechanism…* (RoF b)
…with the GloBox, it's all a bit, been there, done that, now…feel as if we need to, kind of, move on forward a bit more. (GoD)

"Alert Fatigue" has been discussed by Kesselheim et al. (2011), defining the term as the use of *excessive numbers of warnings* (pp. 2310), particularly those relating to non-urgent factors (in their study: not relating to critical drug prescribing). Graham and Cvach (2010) support the notion that a desensitisation to alerts ("alert fatigue") can occur at times of high frequency, which would undoubtedly be the case for hand hygiene during some aspects of Patient care. Combined with the comment from RoFa (Table 6-21) this suggests that "alert fatigue" could potentially result in healthcare professionals missing prompts to action, at the detriment of Patient safety.

As did participants here, Campbell et al. (2007) address the issue of over-dependence on technology within healthcare, defined in their words as when:

> *…those using technological innovations no longer treat them as flexible tools to support work activities, but instead make incorrect assumptions about how*

> *these systems work, and begin to rely on them, without question or scepticism, to manage critical work activities.* (Campbell et al., 2007, pp. 1)

The authors specifically studied CPOE (Computerized Provider Order Entry) across five hospital settings in the USA, observing and interviewing clinical workers. Analysis led to three emergent themes with regard to what were classed as "unintended adverse consequences" stemming from over-dependence on CPOE; i) practice disruption/loss of Patient safety during system disruption, ii) false expectation with regard to data accuracy, iii) perception that clinicians cannot work without CPOE technology. Such themes echo RoF b (Table 6-21) who expressed concern as to how staff would function should any innovation be withdrawn. This could also occur should the individual to be transferred to a different location which was not using hand hygiene technology. Already some of the participants felt uneasy about looking to external triggers to action:

> *I've Nursed for 29 years and I struggle with the concept of needing a "prompt" – hand hygiene should be bread and butter. I understand that some people may need it…* (RoF)

However as commented earlier (Table 6-12), there were equal and opposing comments encouraging the use of external sources, emphasising the bigger goal of hand hygiene over remembering. This is further emphasised by a RoF:

> *I think that's good – how it prompts. Particularly for those areas where you don't always remember to do the hand hygiene…you might say it's a bit false, because it's prompting you, that's – we're here for the Patients… Not for who, or how well somebody's, um, remembering all the time to do something. It's more about making sure we're making the Patient safe. So if you have to prompt somebody every time, and they do it, then that's fine.*

Yet despite such positivity, the evidence for habituation to prompts may suggest that such optimism may be misplaced with regard to long-term usage.

At the case study site, as alluded to by the GoD participant (Table 6-21), the current technology used relating to hand hygiene is the *GloBox* (Figure 6-4).

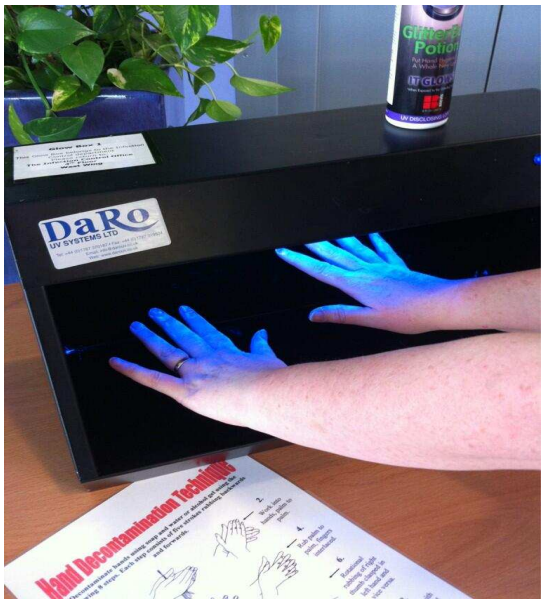


Figure 6-4: GloBox technology is use at case study site to help with the training of Hand Hygiene technique to healthcare professionals

Closely related to work by MacDonald et al. (2006) the GloBox is used to determine efficacy of hand hygiene technique, through the use of UV light and UV sensitive fluid. The latter is used to simulate contamination, and the GloBox is used to show the spread effect on the hand surface. Hand hygiene is then performed with soap and water, and the GloBox is used a second time, the UV light being able to reveal areas missed through the existing technique. Targeted training can then be dispensed to the individual. At this case study site this involves using the Ayliffe technique to focus on which steps may be being missed to cause the specific patches of UV sensitive fluid to remain e.g. rotational rubbing of thumb. Participants revealed that whilst the GloBox had been an effective innovation, allowing instant feedback to illustrate themes of hand hygiene technique, repeated use had led to a lowering of impact, perhaps due to habituation and a loss of novelty.

In sum, a brief discussion between two SoO participants alluded to a reluctance to continually introduce technology into their environment, believing that for their setting verbal communication would be more suitable and adequate:

There's too much [technology] *already...* (SoO a)

>>A lot, particularly in our work, is about passing it on, you know, verbally. (SoO b)

>>It's communication, isn't it..? (SoO a)

Whilst a concern emerged in relation to habituation and over-reliance on hand hygiene technologies, this did not inhibit participants from expressing interest in current technologies. A key factor to successful implementation of future technologies, based on what had worked with the GloBox, was the aspect of novelty, and raising the profile of hand hygiene, as noted by one RoF: *I think they do work, because they do raise, things like that, they do raise the profile of um, hand hygiene and how important it is…*

6.4.1. Embedding FFP analysis into a systems approach

The purposefully designed FFP Matrix (Chapter 3, Figure 3-3) allowed for systematic evaluation of hand hygiene technologies according to specific capabilities. However, the interviews conducted identified that domain knowledge can provide a richness which may also be of benefit to those developing innovations in this area. Understanding which features interest and concern potential end-users could be incorporated into development plans, alongside the existing knowledge as to what current capabilities existing models possess, established through the FFP matrix approach. Within human factors Vicente (2006) proposes the Human-Tech Ladder as a conceptual model to represent how technical solutions to problems can be developed incorporating human behaviour.

Whilst too broad for in-depth discussion here, an adaptation of this conceptual model (taken from Dawson and Mackrill, 2014 – under review), allows its use within the field of hand hygiene technologies to be considered (Figure 6-5).

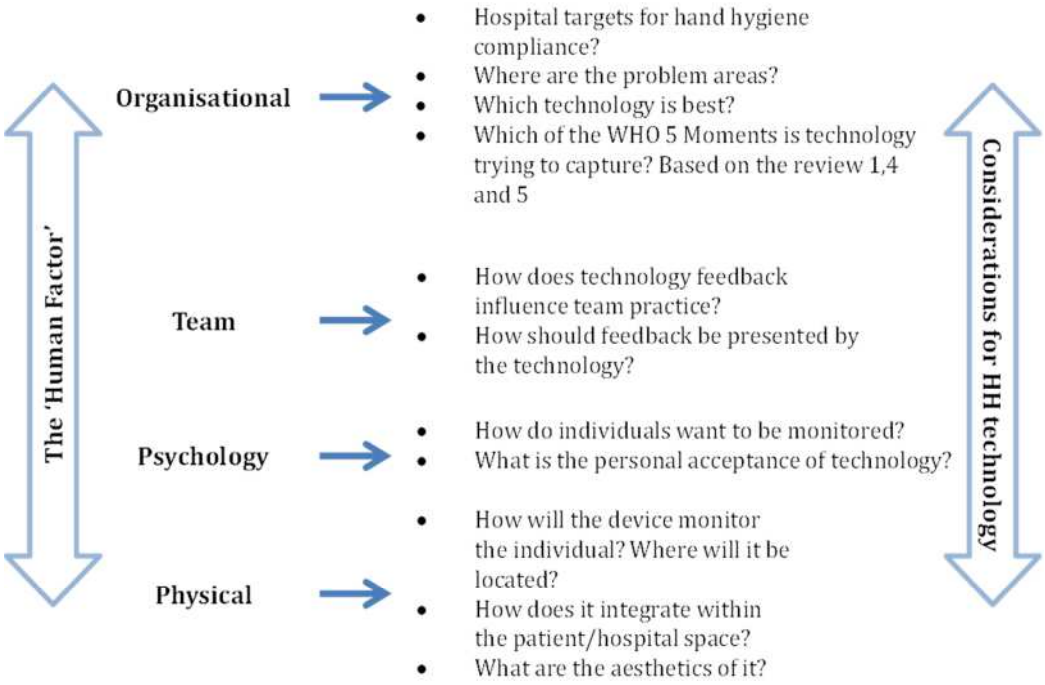


Figure 6-5: A systems way of considering technology for hand hygiene monitoring *Adapted from Vicente (2006), in Dawson and Mackrill (2014 – under review)*

This adapted model allows consideration of issues raised by the participants, including areas of concern regarding anonymity (Psychology), and FFP including context (Organisational) and evaluating technique (Physical). Issues of feedback, established as critical in Study 1 are also addressed through the Team criterion. Such a conceptual model could be created considering the output of a process conducted here, to gather domain knowledge from end users, and provide guidance to technology developers throughout the innovation and development process.

6.5. Potential for Technology within Hand Hygiene measurement

Prompted by three different types of technology examples (Table 6-2) participants demonstrated both interest and concern in the potential of such innovations.

The use of prompting was perceived positively as an aspect of design, and has been shown to improve hand hygiene compliance levels in early studies within the emerging field of hand hygiene technologies. However this issue also evoked concern relating to anonymity and resistance should individual data be required to trigger a prompt, or be stored regarding reactions to such prompts. Concerns were also raised over whether over-reliance and habituation may be the end product of continual exposure to triggers for action.

Fit For Purpose was discussed. Participants agreed that no technology should be seen as a replacement for current methods of measurement, due to inabilities to capture all WHO 5 Moments. However the potential to provide meaningful data at specific Moments was seen as a benefit, giving the potential to aid hand hygiene measurement and compliance. Moment 5 was highlighted as a particular Moment likely to be missed during Patient care, therefore a potential target for future innovations. Currently detection of Moment 5 appears to be at the limit of technological ability, however detection of activity within the Patient Zone is a more notable feature of later innovations. Recognition that this is seen as a concern for healthcare professionals, in correlation with lower levels of hand hygiene compliance at this Moment, may suggest this remains a development priority.

Within user-involvement Shah and Robinson (2006) highlight the importance and growth of healthcare professional involvement in the technology development design lifecycle, particularly at the design stage. It was therefore disappointing to note very few references to such occurrences within the field of hand hygiene technologies. Except for Boscart et al. (2008) no explicit reference to the generation of healthcare professionals opinions regarding innovations were found in the literature reviews conducted. This is not to say that trials involving healthcare professionals and/or healthcare settings have not been conducted, however there appears to be a lack in discussions as part of routine reporting. Findings regarding FFP here suggest technology developers may wish to reconsider allocating resource towards this under explored avenue. The Human-Tech Ladder (Vicente, 2006) is proposed as a potential area of development, with an adaptation for hand hygiene technologies presented for early discussion.

Whilst limitations in current technologies were seen as prohibitive for immediate use, the perception that there was a potential for development of such innovations within hand hygiene was held across all groups of participants (Table 6-22).

Table 6-22: Examples of discussions with participants about limitations of current technologies for immediate use

Participant Quotes
It's starting to give you some degree of confidence but as for the accuracy of everything it's analysing, I'm not sure it's there yet… (RoF)
I mean it's still not 100%...but it's better than what we have at the moment, which is nothing (!). (GoD)
[Researcher: *It may work on a smaller scale?*] *>>Mmm…Perhaps not sensitive enough to do everything we would want to do, all the sensitive bits…* (SoO)

Finally, interviews revealed interesting perceptions with relation to hand hygiene, namely a strong indication that healthcare professionals felt hand hygiene may be more likely on some occasions than others. Aim 2 sought to identify whether specific measurement points (ICNA and WHO 5 Moment) were perceived to be more vulnerable for hand hygiene to be missed at, or more difficult to audit. Findings suggested hand hygiene at activities involving Moment 2 (*Before Clean/Aseptic Procedure)* and Moment 3 (*After Body Fluid Exposure Risk*) would be less likely to be missed by healthcare professionals. Moment 5 (*After Touching Patient Surroundings*) was considered most vulnerable to being missed.

Recorded data from the case study site, analysed as part of Aim 3, revealed some discrepancies between these reported expectations and measured behaviours, such as surprisingly low compliance for 32f *Handling Contaminated Items* (linked to Moment 3). Whilst process issues may account for this in part, the issue of discrepancies between reported and actual hand hygiene behaviour is also well documented (Elridge et al., 2006; Moret et al., 2004; Tibballs, 1996).

6.6. Study Limitations

As with Study 1 the sample for this study, whilst containing participants from each section of the API diagram, was small and limited to IPCT personnel, Nurses, Healthcare Assistants and one Consultant. However, the purpose of the study was to explore participant's views on the potential for technology to improve efficiency and efficacy of hand hygiene measurement. Thus API group was deemed more pertinent than a sample based on professional role. It is possible, however, that different roles may have added further views, and this could be explored in future work.

The field of hand hygiene technology is emergent and rapidly developing, with new products and trials being frequently launched and published. Therefore the use of structured literature reviews to select examples for discussion with healthcare professionals and determine whether current technologies are Fit For Purpose is limited in part by a snapshot approach. Results may not be representative of innovations occurring outside of the date markers selected. Similarly not all technology developers may have published information about their innovations in sources covered by the literature reviews. Whilst expert opinion and alternative sources were consulted to increase the exhaustiveness of the reviews, it is impossible to confirm that all current hand hygiene technologies would have been considered for evaluation.

6.7. Summary

The study revealed that despite limitations of hand hygiene technologies, that no current innovations were found to be able to monitor, measure or provide feedback at WHO Moments 2 and 3, healthcare professionals were still interested in the potential for their use. However, they held concerns which provide significant scope for exploration to increase FFP of hand hygiene technologies.
The lack of technological ability to provide prompting mechanism at Moments 2 and 3 may be less of a hindrance, as participants revealed they perceived hand hygiene at activities related to these Moments to be more “automatic”.
To investigate this further Study 3 was designed as a pilot to explore whether type of activity affects likelihood of healthcare professionals performing hand hygiene, based on the theory of Inherent and Elective hand hygiene.

Chapter 7

Exploring Inherent and Elective Hand Hygiene Behaviour In-situ: A Pilot Study

7. Introduction and Background

Whitby et al. (2006, 2007) suggested that hand hygiene is not a homogenous behaviour, and that the likelihood of it occurring is triggered by the context of the opportunity. A framework of activities around which to observe hand hygiene was at the core of Study 3. This allowed comparisons between the likelihood of participants performing hand hygiene at either Inherent or Elective (Whitby et al. 2006) categories of activities.

Whitby et al. (2006) provide definitions of the terms Inherent and Elective:

> **Inherent:** *Inherent handwashing applies to behavior that is undertaken when hands are physically dirty or feel sticky or when hands have been somewhere considered to be "emotionally dirty" (eg, nurses described axillae, groins, and genitals as "dirty").*(Whitby et al., 2006, pp. 487)
> **Elective:** *Elective handwashing applies to behavior that encompasses all other potential handwashing opportunities.* (pp. 487) *For nurses at work, this component of handwashing behaviour includes nonivasive, impersonal touching of a patient (e.g. taking a pulse or touching inanimate objects in a patient's environment).*(Whitby et al., 2006, pp. 490)

Their 2006 work also provided sub-categories of activities classified as *in-hospital Inherent or Elective handwashing* (pp. 487), (Table 7-1).

Table 7-1: Further classification of activities leading to hand hygiene as defined by Whitby et al. (2006): In-hospital Inherent and In-hospital Elective

In-hospital Inherent handwashing	In-hospital Elective handwashing
After performing a wound dressing	After touching autoclaved materials
After making an incontinent Patient's bed	After touching the hospital's telephone
After performing a mouth toilet	After touching a Patient's furniture
After changing a urine bag	After arranging flowers at work
After dressing an infected wound	After rubbing a Patient's back
After touching a Patient's groin	After taking a Patient's temperature
After defecating	After sponging a Patient
After emptying a soiled bed pan	After shaking hands with a Patient
After touching a Patient's armpit	After touching a Patient's feet
	After blowing my nose
	After taking a Patient's pulse
	After touching a Patient's breast
	After using someone else's computer

7.1. Study Objective and Aims

The study objective was *To investigate the impact of Inherent and Elective hand hygiene trigger activities on hand hygiene behaviour in an NHS acute setting.*

This was underpinned by two separate aims (Table 7-2), which determined the choice of methods for data collection and analysis.

Table 7-2: Individual aims underpinning Research Objective for Study 3

Aim No	Aim
Aim 1	Categorise Inherent and Elective trigger activities using literature and data collected from Studies 1 and 2, in collaboration with field experts from the case study site (IPCT)
Aim 2	Using observation in an NHS acute setting, determine whether rates of hand hygiene compliance in healthcare professionals differ for Inherent and Elective trigger activities

7.2. Method

7.2.1. Developing an Observation schedule

For the purpose of the present study the activities identified as in-hospital Inherent or Elective (Table 7-1) were combined with activities that emerged from discussions during the interview phases of Studies 1 and 2 (Table 7-3). During Studies 1 and 2 GoD were asked to give examples of what constituted activities relating to specific statements currently being used to perform hand hygiene auditing (ICNA points 32 a-g). This was to clarify whether standardisation occurred (Study 1) and whether any of these points were perceived as harder to audit or perform hand hygiene correctly at (Study 2). These examples were included to add specific NHS based context to Study 3.

Table 7-3: Examples of activities classified under specified ICNA hand hygiene audit points, used at NHS case study setting, generated from Studies 1 and 2

Examples and Context provided from Studies 1 and 2 for ICNA Points
ICNA Point 32a: *Following Patient Contact* Example activities classified as Patient Contact: *Helping Patient sit up in bed, Arranging Patient Pillows*
ICNA Point 32b: *After Removal of Gloves*
ICNA Points 32c, d: *Prior to Clinical Procedures, After a Clinical Procedure* **(Clarifying Prompt used in Study 1: What is a Clinical Procedure?)** Example activities classified as clinical procedures*:* *Taking Patient blood pressure, Filling/aspirating an NG tube, Helping a Patient wash, Changing a dressing, Taking a Patient temperature, Setting up an IV Line, Carrying out observations, Manipulating a Urinary Catheter, Taking a blood sample*
ICNA Point 32f: *After Handling Contaminated Items* **(Clarifying Prompt used in Study 1: What is a Contaminated Item?** Example objects classified as contaminated items: *Patient Bed, Soiled Linen, Ward based Blood Pressure machine, Item tainted by bodily fluid* *(*NB: Idea of all items being Potentially Contaminated within Patient Zone)
ICNA Point 32g: *After leaving an Isolation Room* NB: hand hygiene required at all exits, regardless of activity performed within room (unless no hand-Patient/surface contact occurred).

The 15 examples specifically identified through this process (highlighted in non-bold italics in Table 7-3), plus the clear actions outlined by points 32b and 32g, were then provisionally categorised as Inherent or Elective based on the researcher's interpretation of the existing theory of Whitby et al. (2006, 2007). Following the process of member checking (Baxter and Jack, 2008), this categorisation was then cross-referenced with members of the GoD group for

validation. These individuals were provided with the original definitions of Inherent and Elective hand hygiene, and asked whether they felt the categorisation of each activity was correct. Discussion and clarification occurred and a consensus was reached (Table 7-4).

Table 7-4: Translation of Table 7-3 examples of ICNA point activities, categorised as Inherent or Elective activities, validated by GoD participants

Inherent Activities	Elective Activities
Filling/aspirating an NG tube	Helping Patient sit up in bed
Changing a dressing	Arranging Patient pillows
Setting up an IV line	Taking Patient blood pressure
Manipulating a urinary catheter	After leaving an isolation room
Taking a blood sample	Taking a Patient temperature
(Handling) soiled linen	Carrying out observations
(Handling) item tainted by bodily fluid	(Touching a) Patient bed
	After removal of gloves
	(Touching) ward based blood pressure machine
	Helping a Patient wash

From this only one change was made. *(Handling) Item tainted by bodily fluid* was removed as participants felt it replicated *(Handling) soiled linen* too closely.

7.2.2. Observation sheet validation

Finally the two lists (Table 7-1 and Table 7-4) were merged to create one list containing examples from the original source literature and from the NHS setting (Table 7-5). Due to similarities, the activities *(Touching a) Patient bed* and *After touching a Patient's furniture*, and *(Touching) ward based blood pressure machine* and *Taking Patient blood pressure* were merged. The remaining list, 22

from original literature (Whitby et al. 2006) and 14 from the case study was discussed with GoD to identify the likelihood of being able to observe activities within the cardio-thoracic setting, based on their experiences of hand hygiene auditing (experience confirmed via interview in Study 1). From this six activities were removed from the list. These were deemed highly unlikely to be observed, either due to rarity or due to Patient/healthcare professional confidentiality issues (e.g. would only be performed out of view of an observer).

Table 7-5: Merged list of activities, split by origin (Whitby et al. 2006 or case study site), highlighting the six activities removed after discussion with GoD

Inherent Activities	Elective Activities
From original literature	
After making an incontinent Patient's bed	After touching the hospital's telephone
After performing a mouth toilet	After sponging a Patient
After dressing an infected wound	After using someone else's computer
After touching a Patient's armpit	After touching a Patient's feet
After emptying a soiled bed pan	After taking a Patient's pulse
After changing a urine bag	After taking a Patient's temperature
After performing a wound dressing	After rubbing a Patient's back
	After shaking hands with a Patient
	After blowing my nose
	After touching a Patient's furniture
Site Specific Examples	
Changing a dressing	Helping a Patient wash
Taking a blood sample	After leaving an isolation room
Manipulating a urinary catheter	Taking Patient blood pressure
Setting up an IV line	After removal of gloves
(Handling) soiled linen	Helping Patient sit up in bed
	Taking a Patient temperature
	Arranging Patient pillows
	Carrying out observations
Examples removed after discussion with GoD (unlikely to observe)	
Filling/aspirating an NG tube	After touching autoclaved materials
After defecating	After touching a Patient's breast
After touching a Patient's groin	After arranging flowers at work

7.2.3. Field Note commentary

The trigger activities (Table 7-5) were used as a guide for both categorisation and observation. However this did not form exclusive inclusion criteria for which activities were observed. All observed instances of hand hygiene were recorded, along with the activity immediately preceding (where possible) or following. Contextual information was recorded from the moment of a trigger activity occurring, to the next trigger activity. This method was similar to that of the WHO 5 Moments technique whereby observers calculate compliance by observing hand hygiene opportunities (WHO 2009e). The current approach allowed discrimination between merged moments and identification of additional themes for discussion. This method took guidance from Boscart et al. (2010) who observed the presence of merged moments when Patient care took place within multi-bed rooms. An example of a merged moment is when hand hygiene is performed at Moment 4, and no contamination then occurs before a Moment 1 occurs within another Patient Zone (Figure 7-1).

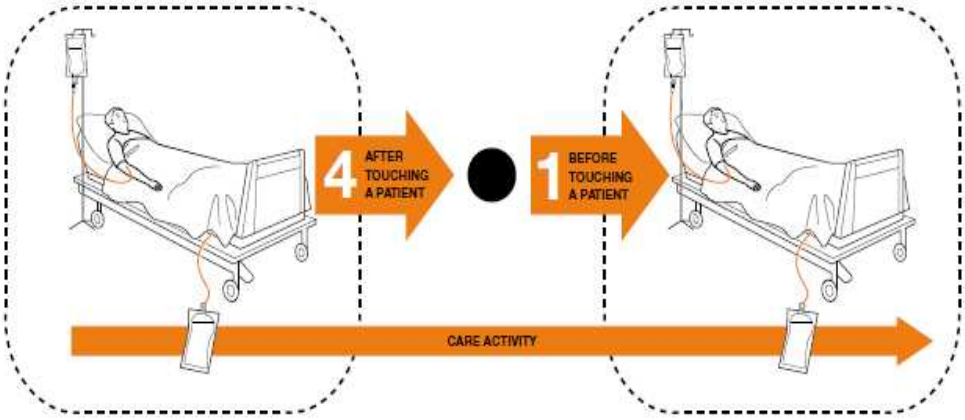


Figure 7-1: Example of merged moments: Hand hygiene at a singular point (represented by the black dot) would be sufficient to ensure a break in potential cross-contamination *(Reproduced from WHO Hand Hygiene Technical Reference Manual, pp. 16)*

Thus, recording of contextual information allowed such considerations to be acknowledged, and reduced the likelihood of false negative scores being collected. In this example (Figure 7-1) a false negative score could be if no hand hygiene was recorded at a Moment 1, without acknowledging this was due to hand hygiene already being performed at a Moment 4, with no further potential contamination occurring prior to the Moment 1.False negative scores are discussed in more detail previously, (see pp. 274), highlighting the need for an ability to record context when measuring hand hygiene.

Finally the contextual information was also useful to track hand hygiene within the busy NHS setting. Similar to the WHO 5 Moments approach for observing hand hygiene compliance, hand hygiene could be expected either before or after a trigger activity. Making notes on the actions of the healthcare professional helped provide a record of all activity either side of each episode of observed hand hygiene.

7.2.4. Study Site

The study took place within the cardio-thoracic unit of the case study site, comprising a surgical step-down unit, two areas divided into gender specific bays, and a number of side-rooms for isolated Patient care (Figure 7-2).

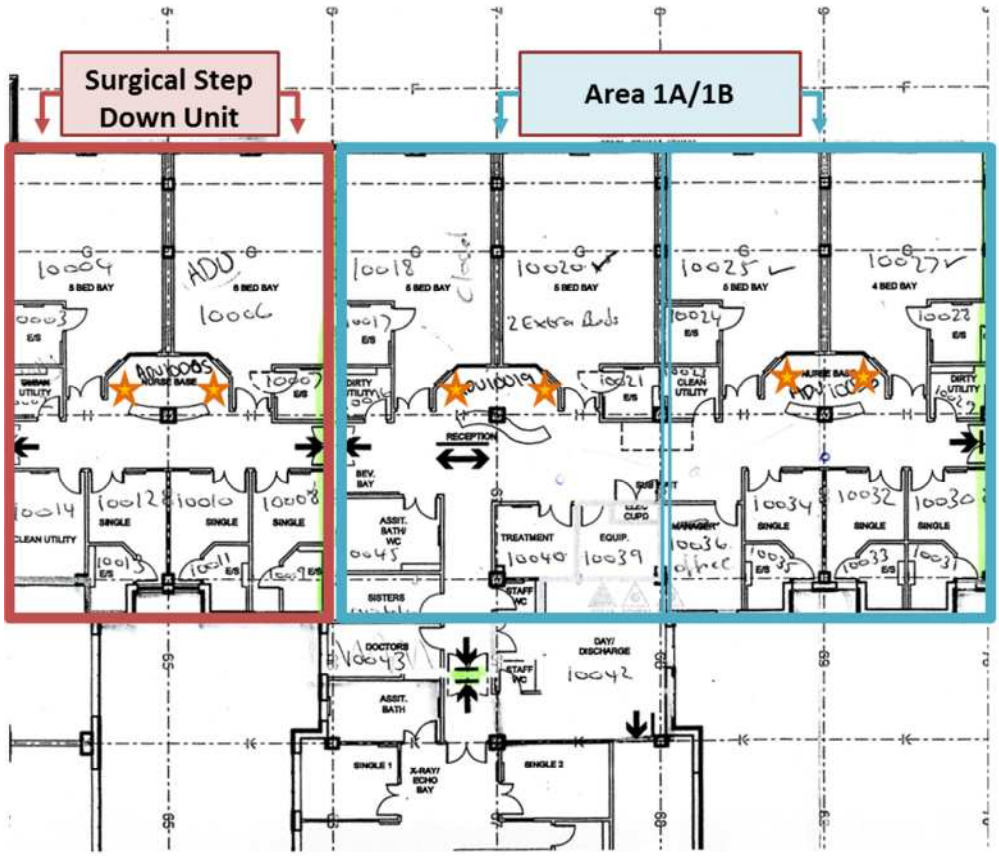


Figure 7-2: Overview of clinical setting for Study 3
(Stars indicate main locations for observations, allowing maximum opportunity for direct, yet unobtrusive observation into bays, single rooms and corridors/nursing stations)

The rationale for the selection of this ward stemmed from discussions held during the previous interview stages required for Studies 1 and 2. Participants from this setting highlighted the variety of workload and Patient care needs, offering opportunities to observe both Inherent and Elective trigger activities. Patients required intravenous medication, often having post-operative drains and open, dressed wounds (linked to Inherent trigger activities) as well as staff carrying out regular observation and drug rounds (linked to Elective trigger activities). The Modern Matron, Ward Manager and Practice Development Nurse were all enthusiastic about the potential for the unit to be involved in further research

about hand hygiene. The ward had recently participated in other academic research (Mackrill, 2013), therefore staff understood requirements for informed consent and were aware of collaborations with the researcher's academic institution.

7.2.5. Sample

A sample size of 20 participants (nurses/healthcare support workers) was calculated using an online sample size calculator (www.Statstodo.com, 2013) for the McNemar test of difference, with the parameters $\alpha = 0.05$, power = 0.9. Data gathered from participatory observations in Study 1 (*N*=10) and discussions with participants in Study 2 regarding frequency of observed hand hygiene at specific activities (*N*=20) was used as a basis for the McNemar sample size calculation. This data resulted in an estimated expected difference between the likelihood of performing hand hygiene at an Inherent trigger but not an Elective trigger, and the reverse, being determined (Table 7-6).

Table 7-6: Expected outcomes of hand hygiene behaviour after Inherent or Elective trigger activities, used to determine powered sample size required

Hand Hygiene Trigger (Hand Hygiene Performed?)	**Estimated Chance of Occurrence**
Elective (*YES*), Inherent (*NO*) = (*EY/IN*)	0.15 (15% chance)
Inherent (*YES*), Elective (*NO*) = (*IY/EN*)	0.8 (80% chance)

Hand hygiene was expected to be much more likely when healthcare professionals were confronted with an activity classified as Inherent (e.g. after changing a urine bag) than when the activity was classified as Elective (e.g. arranging Patient

pillows). The null hypothesis predicted no difference between hand hygiene rates for trigger activities classified as either Inherent or Elective.

Each participant contributed two data points, one relating to their hand hygiene response to an Inherent trigger activity, the other relating to their hand hygiene response to an Elective trigger activity.

7.2.6. Mediation for effects of Direct Observation

Direct observation has previously been identified as the gold standard method for measuring hand hygiene, yet it possesses limitations relating to both observer and subject behaviour. Systematic reviews in the area (Braun et al., 2009; Erasmus et al., 2010; Haas and Larson, 2007; Gould et al., 2007b), have highlighted the tendency for weakness in design and reporting of methods leading to a lack of clarity and/or validity of results. In light of such considerations the present study attempted to counter some of the recognised weaknesses by implementing simple interventions to mediate the potential confounders of the Hawthorne effect and observer bias. Covert observation was not used due to considerations of potential future negative feeling and mistrust which may hamper hand hygiene promotional activities (Earl et al., 2001).

a) Hawthorne Effect/Observer Bias

Observation bias is known to affect the behaviour of those under review, leading to a positive skewing in recorded hand hygiene rates (Eckmanns et al., 2006; Kohli et al., 2009). To reduce this effect the data collected within the first 15 minutes of each observational period was not used for analysis. It was considered that during this time a heighted behaviour change on behalf of the participant

would be apparent. The timing of 15 minutes was decided based upon discussions with the IPCT, observed behaviour changes during the Study 1 participatory observations, and to ensure sufficient time remained to collect data for analysis.

Further, up to six examples of trigger activities from each category were observed within the hour period before the session with a participant was deemed to be complete. Only one from each category was selected for analysis, using an online random number generator (www. Mathgoodies.com, 2013). This reduced the potential for participant performance effects causing positive skew of hand hygiene compliance. The random selection of data for analysis also prevented the researcher from influencing the selection of incidents to include.

Observatory sessions were limited to one hour. This time period was selected due to the acknowledged risk of observer fatigue (Stone et al., 2010), whereby longer periods of observation may risk a lack of recording accuracy by the researcher.

7.2.7. Data Collection

Data was collected over ten days between 15th January and 20th February 2013, totalling in 956 minutes of observation, recording 119 HHO. Of these 55 occurred during the morning (between 9am and midday) and 64 occurred in the afternoon (between 2pm and 4.30pm). Guidance was sought from the Ward Manager as to appropriate times for observation. As such no observations were carried out during protected meal times, or the rest hour held directly after lunch. Both these decisions were taken in the interests of the Patients and were not felt to impact upon the design of the research.

Observatory sessions lasted up to one hour or until a participant had been seen performing six Inherent and six Elective hand hygiene trigger activities. Sessions were paused when a participant left the clinical area for a break or their shift ended, and were continued at a later time/date.

An information sheet (Appendix 5a) was produced specifically for the study, and the researcher was available to answer additional questions throughout the study period.

Data collection began as soon as consent was agreed with the participant, with the researcher agreeing a suitable location from which to safely observe the clinical area whilst maintaining appropriate Patient confidentiality/comfort (predominantly as indicated in Figure 7-2 but also including discrete locations within multi-bed bays). Agreement with both participants and the Ward Manager allowed the researcher to relocate should the participant move out of line of sight, unless this involved entering a Patient side room or area which would clearly infringe upon Patient privacy.

Two forms of data were collected: binary scores for whether hand hygiene was performed in relation to the trigger activity, and also field note commentary to provide context to variables surrounding the event. As this study was a pilot study investigating an emerging hypothesis, collecting contextual data offered the opportunity to reflect on design improvements for future work. All data was recorded manually with the researcher using a standard paper and pen technique, with notice of time recorded at the start and end of each observatory period, and at intervening five minute segments. Recorded data was kept confidential, and if

questioned by any staff, Patients or visitors to the unit, the researcher explained they were carrying out research into hand hygiene.

7.3. Analysis

All instances of hand hygiene observed by the researcher were recorded, with field note commentary used to add context. This facility allowed the recorded events of hand hygiene to be mapped to the original trigger activity events (Table 7-5) away from the pressured environment of the observation.

This was particularly useful as the trigger activity list was not easy to remember in conjunction with observing and recording hand hygiene, and not all activities observed were a perfect fit with the original wording of the list. For example, the activity of *Handling a clean bed pan* did not feature on the original trigger activity list, however seemingly fits with the concept of *in-hospital inherent*, within the concept of *emotionally dirty*. This assumption was validated through discussion with healthcare professionals during this study[15]. Data was therefore attributed a context (description as recorded from field note commentary), main category (from Table 7-5), and source (linking it to either the original literature of Whitby et al., 2006, the ICNA tool, or the WHO 5 Moments) – see Appendix 5b for full list. The result of this activity was an adapted framework which considered the NHS specific context, discussed shortly.

After each observatory session, binary data was transferred from the field note commentary capture sheet to a standardised form (Appendix 5c). Once data from

[15] GoD participants were asked whether they considered handling clean bed pans an example of an 'emotionally dirty' activity, that they believed would drive hand hygiene automatically, to which consensus was universal (6/6 positive responses). The example was then used in discussion at 2 national and 1 international conferences (Appendix 6a) to illustrate Inherent/Elective hand hygiene theory, to favourable response.

all 20 participants had been collected it was uploaded into Microsoft Excel for analysis, with the McNemar test of significance calculated by hand.

7.4. Results

In total 31 Inherent and 88 Elective trigger activities were observed from the 20 participants, with no observatory session achieving a maximum observation figure of 12 activities (six Inherent, six Elective). One participant was observed performing more than six Elective activities, thus no record was taken of their Elective hand hygiene behaviour after the first six activities. The majority of participants (14/20) were only recorded performing one Inherent activity, consistent with the expected difficulties regarding Patient confidentiality and scarcity of such activities occurring in comparison with Elective activities.

Using an online random number generator data points from each participant were reduced to one Inherent and one Elective entry, leaving 40 observations for analysis: 19 coming from morning sessions and 21 coming from afternoon sessions.

7.4.1. Test of significance

Thirteen of the participants performed hand hygiene for Inherent triggers but not for Elective triggers, whilst seven of the participants performed hand hygiene universally, for both Inherent and Elective triggers. This difference in behaviour was found to be significant according to the McNemar test of significance: χ^2 (df 1) 11.077, p=<0.001. Therefore the null hypothesis could be rejected.

7.5. Discussion

7.5.1. Identification of Inherent and Elective trigger activities on an NHS ward

Study 3 developed a framework for categorising clinical activities into Inherent or Elective trigger activities. This was then tested during the observational phase designed to meet Aim 2.

The framework included activities identified by Whitby et al. (2006) and activities identified through Studies 1 and 2 of this research (see 7). Once the observational phase was complete actual observed activities were compared with those within the framework (Table 7-5) and allocated a context, main category, and a source (see 7.3, and Appendix 5b).

On 28 occasions (from 119 data points collected), where a recorded activity did not fit with a trigger activity (main category) or source, consultation was held with a GoD participant to determine whether these examples demonstrated standard hand hygiene as would be measured during regular auditing.

All points were considered standard. They were allocated a source of either 5 Moments or PPE. This indicated their inclusion came from hand hygiene expectations stemming from the WHO 5 Moments or Personal Protection Equipment guidelines.

This process allowed verification of the data for analysis for the present study, and development of a novel framework, incorporating clinical activities and aspects of

the 5 Moments, for future use in identifying or observing Inherent and Elective activities in a clinical setting (Table 7-7).

Table 7-7: Novel framework incorporating Hand Hygiene Opportunities (HHO) from the tested framework (Table 7-5), and five emergent HHO examples (shown in italics)

Inherent Activities	**Elective Activities**
Personal Actions	**Personal Actions**
	After blowing my nose
Clinical Duties	**Clinical Duties**
Manipulating a urinary catheter	After rubbing a Patient's back
After changing a urine bag	After touching a Patient's feet
After emptying a soiled bed pan	After shaking hands with a Patient
Taking a blood sample	After removal of gloves
Setting up an IV line	After sponging a Patient
After dressing an infected wound/changing a dressing	Helping a Patient wash
After performing a mouth toilet	Carrying out observations
After touching a Patient's armpit	After taking a Patient's pulse
After intimate washing of a Patient (groin, armpit)	After taking a Patient's temperature
	Taking Patient blood pressure
	Helping Patient sit up in bed
	Before Patient contact (any not covered)
	After Patient contact (any not covered)
	Before putting gloves on
Interaction with Environment	**Interaction with Environment**
Handling soiled linen	After touching a Patient's furniture
After making an incontinent Patient's bed	Arranging Patient pillows
After handling a clean bed pan (Emotional Driver)	After leaving an isolation room

This framework incorporates examples from the original work of Whitby et al. (2006), examples from healthcare professionals at the case study site, and five examples which emerged from the current study. As a result some of the original Elective examples were removed due to their lack of perceived Patient focus, based upon a WHO 5 Moments approach whereby hand hygiene is focused around the Patient zone. Therefore observing actions around, for example, *After touching the hospital's telephone*, is not seen of primary interest for future work in this area. Even if hand hygiene did occur at this point, there is a possibility that contamination could occur again prior to any subsequent Patient care occurring. New examples based on activities more frequently seen within the NHS setting (e.g. *Before Patient contact (any)*) have been incorporated into the framework, as well as the emotional driver of *Handling a clean bed pan*. For additional clarity both Inherent and Elective activities have been divided under three headings, to reflect where opportunities for observation may be most likely (e.g. clinical activities usually require Patient interaction, personal actions do not).

This framework may provide the basis for future replication studies, and could be further adapted to incorporate context specific examples based on interviews and experiences of those based at a particular location (see 7.6.4.).

Of the 40 data points randomly selected for analysis these represented 15 trigger activities (main categories) and all four possible sources, split as per Table 7-8.

Table 7-8: Inherent and Elective trigger activities randomly selected for analysis, showing original context comment, allocated main category and source, with frequency of observations (obs.) and hand hygiene events (HHE)

Context	Main Category	Source	No. of Obs.	HHE
Inherent Trigger Activity				
Helping change a Patient bed - removing soiled lined to sluice room	Handling soiled linen	ICNA	8	8/8
After setting up an IV line	Setting up an IV line	ICNA	4	4/4
After handling clean bed pan	Emotional driver	Whitby	2	2/2
After intimate washing of Patient	After touching a Patient's groin; after touching a Patient's armpit	Whitby	2	2/2
After removing catheter	After changing a urine bag;	Whitby	1	1/1
After removed gloves after cleaning used commode (with gloves on)	After emptying a soiled bed pan;	Whitby	1	1/1
Disconnecting catheter	Manipulating a urinary catheter	ICNA	1	1/1
Changing a wound dressing (behind curtain)	Changing a dressing	ICNA	1	1/1

Elective Trigger Activity				
After touching Patient surroundings (Patient bed)	After touching a Patient's furniture;	Whitby	10	3/10
Before entering side room (Patient area) – contact with Patient (hand holding)[16]	Before Patient contact	5 Moments	3	1/3
After performing Patient observations (blood pressure/temperature)	After taking a Patient's temperature;	Whitby	2	2/2
Before putting gloves on	Before glove use	PPE	2	0/2
After removing gloves, apron, (after cleaning Patient equipment - drip stand)	After removal of gloves	ICNA	1	1/1
Before Patient contact (checking Patient wristband)	Carrying out observations	ICNA	1	0/1
After helping Patient out of bed	Helping Patient sit up in bed	ICNA	1	0/1

[16] For observations where Context was "Entering Side Room" or "Patient Area" data was only recorded if Patient Contact followed imminently. Hand hygiene was not expected just because of entering a particular area.

For some of the trigger activities shown there were multiple contexts. For example, *After touching a Patient's furniture* included touching ward equipment (e.g. drug trolley), moving Patient belongings, touching Patient curtain and touching Patient equipment (EEG machine). Similarly *Setting up an IV line*, included both before manipulating Catheter/IV Lines and after setting up an IV line. Therefore Table 7-8 should not be seen as an exhaustive reference list of contexts for each Main Category.

Whilst frequency counting was not a study aim, the data collected provides interesting reading. Of all hand hygiene events randomly selected for analysis (Table 7-8) those relating to the Elective activity *Touching Patient Surroundings* generated the highest frequency (*N*=10). However this activity, known to be a risk point for cross-contamination and thus explicitly included in the WHO 5 Moments (Moment 5) is widely reported to generate low levels of hand hygiene (Rossini et al., 2013; Grayson et al., 2011). Participants voiced the perception that activities relating to Moment 5 would generate lower levels of hand hygiene than those at other Moments during Study 2. In accordance with these findings and perceptions the results of Study 3 found that for this specific activity hand hygiene was only performed on three out of the ten observations.

7.5.2. The effect of trigger activity type on likelihood of Hand Hygiene

The observational phase returned a statistically significant finding: χ^2 (df 1) 11.077, p=<0.001. This suggested a higher likelihood that a nurse/support worker would perform hand hygiene when met with an Inherent trigger activity than an Elective trigger activity.

This supports Whitby et al. (2006), who reported that nurse participants did not consider all activities equal in their need for hand hygiene (Chapter 3). They used nursing staff from two large tertiary care referral hospitals in Australia as source material, which may have led to differing work experiences providing Inherent and Elective examples. Therefore this research developed a bespoke framework incorporating examples from healthcare professionals at the NHS case study site.

Dirtiness was found to be a key driver by Whitby et al. (2006), either emotional[17] or physical. Such a conception was found to be present in both healthcare professionals (nurses), mothers, and children (9-10 years old). Further, the involvement of children and perceived primary care-givers (i.e. mothers) allowed the authors to investigate the potential development of attitudes to hand hygiene. Of relevance to the current study, this includes decisions on the effect of context on the likelihood of hand hygiene action being taken. For example:

> *Mothers and nurses agreed that handwashing in the home is of lesser importance; thus, the decision by children to wash hands was strongly influenced by situation. A risk assessment based on the perceived likelihood that harmful microorganisms are present is made before deciding whether to wash hands in public areas (eg, shopping centers and playgrounds) considered more likely than homes to harbor harmful "germs".*
>
> (Whitby et al., 2006, pp. 486)

The authors suggest a "Hierarchy of Risk"[18], employed by healthcare professionals during periods of intense workload. This hierarchy may be developed in childhood, from the external guidance of role models (i.e. primary

[17] Emotional dirtiness – whereby hand hygiene is desired without necessarily physical soiling of hands being present, due to touching an item/area which triggers a strong urge for decontamination e.g. another person's armpit - see pp. 153

[18] "Hierarchy of Risk" – internal requirement assessment processes based on need for hand hygiene at specific moment, within which a key driver is concept of 'dirtiness' – see page 157 for further discussion

care givers) and form the basis of long term behavioural tendencies. Unlike the influence of senior and peer role models, which may affect the likelihood of performing hand hygiene at specific instances (2.6.2. d. ii), the behaviours transferred from role models in childhood are not seen to be transitory. Alongside evolutionary, reactionary behaviours, they form the essence of Inherent hand hygiene.

The influence of community behaviour was seen as the primary influencing component for both Elective and Inherent in-hospital hand hygiene intention by Whitby et al. (2006) leading to the formation of the original theory. Both Inherent and Elective community behaviour were found to be influential components for Inherent in-hospital hand hygiene intention. This influence ranked higher than components including attitudes and perceived peer behaviour. Such an influence leads individuals to develop and reinforce personal models of hand hygiene, which are well established long before potentially entering the healthcare profession (Whitby et al., 2006). These models, based on community expectations and standards, with drivers linked to concepts of dirtiness and self-protection may not correlate with the microbiologically driven standards required within healthcare. Hand hygiene would be expected, as found in the presented study, to be higher at instances where a match occurs between the existing model and that required within the healthcare setting, predominantly revolving around Inherent activities e.g. contact with bodily fluids.

Further support for the influence of human behaviour, comes from the previously described work of Otter et al. (2006). In their study, exploring the impact of environmental contamination (see 2.3.1.), it was more likely to find MRSA

contamination on areas such as Patient bedside rails and blood pressure cuffs, than toilet seats and IV pumps. In the present study these more contaminated areas would relate to activities categorised as Elective (e.g. after touching a Patient's furniture; taking a Patient's blood pressure), thus less likely to result in hand hygiene. This is opposed to the less contaminated areas which would relate to activities categorised as Inherent (e.g. setting up an IV line), thus more likely to result in hand hygiene. The indication, therefore, is that greater guidance may be of use with regard to the need for hand hygiene for Elective activities, not simply because healthcare professionals are less likely to perform hand hygiene, but because there may be higher levels of environmental contamination risk associated with such activities. Links into perceptions of dirtiness by those responsible for cleaning specific areas, using an Inherent and Elective framework (e.g. toilet seats vs. bed rails) may be an interesting avenue for future discussion, falling outside of the scope of the current research.

7.6. Study Limitations

7.6.1. Hawthorne Effect

Whilst efforts were taken to reduce observation effects it is accepted that the recorded hand hygiene levels may reflect a positive skew due to the presence of an overt observer.

In 6 out of 20 observations participants either physically responded to the introduction of the researcher by performing hand hygiene, or commented that they had just done so, or were about to. This seemed to indicate a desire to please effect. Similarly on a number of occasions (N=5) throughout the observation

sessions participants appeared to perform detours in order to perform hand hygiene at sinks located closest to the researcher's observatory position, rather than using either the sink located next to where they had performed the hand hygiene trigger activity, or ABHR gel dispensers located near-by (e.g. at point-of-care within Patient Zone). These apparent desire to please events were recorded via the field note commentary. It was not, however, the aim of the study to attempt to monitor such issues, or investigate the apparent impact of the Hawthorne effect on the participants' behaviour. Therefore no definitive judgement on the scale of their impact was made. It was noted, however, these behaviours of a very overt nature decreased as the observation period elapsed. This lends support to the use of the false start 15 minute period, during which time no data was recorded for analysis (see 7.2.6.).

7.6.2. Generalisability

The study involved a sample size of 20 participants, as calculated to provide a strong power (0.9) with anα value of 0.05. However, it is acknowledged that the sample contained only female nurses and support workers from a single setting (cardio-thoracic ward) within a UK NHS acute Trust, thus the study findings may lack generalisability to a wider more varied population. The decision not to dilute the sample with other members of the cardio-thoracic clinical team (e.g. doctors, consultants, male personnel) stemmed from the well-documented effects of such variables on hand hygiene compliance (WHO, 2009; 2.6.2.d.i). Here the aim was to maintain as much homogeneity within the sample as possible, to allow the activity to be the key variable liable to be affecting hand hygiene compliance.

7.6.3. Hand Hygiene Trigger Activity: Identification of Event Order

The study objective was to determine whether there was a difference between hand hygiene behaviour of participants when faced with different clinical duties, categorised as Inherent or Elective trigger activities. As hand hygiene is a preventative measure performed both before and after clinical activity (WHO, 2009e) there are times when a direct link between a hand hygiene event and clinical activity may not be apparent: for example if multiple activities occur within the Patient Zone after hand hygiene has correctly been performed. In such circumstances it may be impossible to directly attribute, with certainty, the hand hygiene to any one of the actions performed. Figure 7-3 demonstrates this visually, using an example observed during the present study.

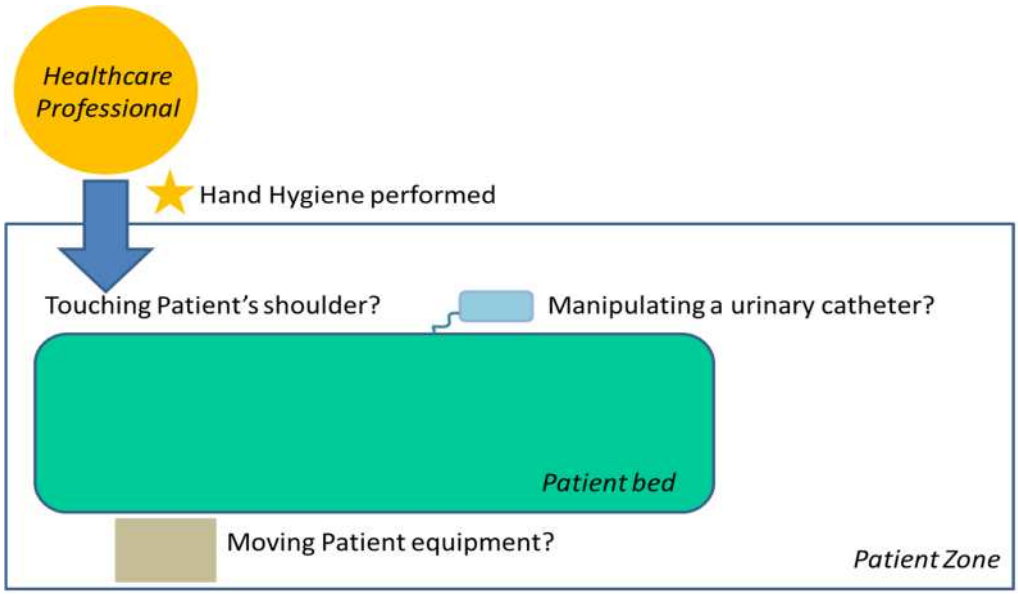


Figure 7-3: Sequence of events from Study 3 highlighting difficulty identifying hand hygiene motivation when observing multiple activities

Here a healthcare professional entered a Patient Zone, performing hand hygiene upon entry. They then performed three separate activities in succession: touching the Patient's shoulder as they said "hello", touching and checking the urinary

catheter, and then moving the Patient's table. When asked (by a colleague) what they were currently doing, they stated they were *checking on* [Patient name]*'s catheter*, inferring that this was the activity that had prompted entry to the Patient Zone, thus triggered the performed hand hygiene.

However, from the observation alone this would not have been apparent, as the first activity requiring hand hygiene to have been performed would have been touching the Patient shoulder (Moment 1). The intended trigger activity for hand hygiene, the checking of the catheter, would have subsequently required further hand hygiene, due to its distinct categorisation as a Moment 2 (clean/aseptic technique), as flora from the Patient could be transferred to the catheter bag by the hands of the healthcare professional, as discussed in Chapter 2. Hand hygiene would then have been required after checking on the catheter (Moment 3), prior to moving the Patient's table.

To attempt to work with this limitation, the study employed the use of the field note commentary to provide contextual information around each of the hand hygiene events captured. This gave information on the activities preceding and following each hand decontamination. Inferences were then able to be made as to whether or not to include the trigger activity/hand hygiene performed score in the analysis. Therefore for the study, only clearly linked hand hygiene and activities were included for the analysis.

7.6.4. Context and Habituation

The theory of Inherent and Elective hand hygiene, that different triggers will lead to differing levels of hand hygiene, is supported by the findings of Study 3.

However, the current approach, using a framework to categorise ward duties into definitive Inherent or Elective trigger activities requires further testing, based on the potential effects of context and habituation.

Findings from Curtis et al. (2009) and Marjadi and McLaws (2010) suggest that community and cultural tolerance of dirty hands may affect rates and decisions of when to perform hand hygiene. As community hand hygiene behaviour is postulated as a key influencing variable of subsequent healthcare professional hand hygiene behaviour (see 7.5.2.), the framework developed here may not be fully suitable for all settings or geographical locations. The use of explicit references from the NHS context from where observations were based allowed relevance for the current work, and similar settings, however the incorporation of views regarding community behaviour within the UK may have been of further benefit.

Interestingly, Nicol et al. (2009) found a process of desensitisation may take place in the perceptions of healthcare professionals. Participants in their study reported that familiarity over time with aspects of work that may pose potential infection risks without experiencing negative consequences (i.e. becoming infected/experiencing a risk), led to the activity no longer being seen in the same risk category. This effect was named "superman theory" by participants, relating to a belief that they were unlikely to be personally infected carrying out such activities or working in the particular environment.

This has important implications for the present study, and theory based upon hand hygiene being motivated by themes of self-protection and fear. It could be expected, according to this finding by Nicol et al. (2009), that repeated experience

of risky procedures which lead to an instinctive desire for hand hygiene (e.g. exposure to body fluid risk) without negative consequences (e.g. infection, illness) may reduce the initial instinctive desire. A process of habituation, similar to that discussed in Study 2 in response to the reduction in effectiveness of technology prompts over time, may be seen to occur. Further work in this area is recommended, and is discussed shortly.

In support of the notion of Nicol et al. (2009), that context may affect perceptions of risk to self, the previously discussed work of Efstathiou et al. (2011) also adds an interesting dimension (see 2.6.2.a). Their research, which found that healthcare professionals viewed adult and child Patients differently in terms of potential sources of risk, suggests that not only the category of activity (i.e. Inherent vs. Elective) but also the category of Patient (i.e. adult vs. child) may need to be taken into account in future research. Hand hygiene rates exhibited by healthcare professionals performing Elective activities with adult Patients may be found to be higher than those exhibited in those performing Inherent activities with child Patients, depending on which driver (activity or Patient) is perceived to be stronger.

7.7. Future work

Study 3 was a pilot study, and provides an interesting number of opportunities for further extension and development of emergent themes.

Firstly, replication using additional observers to test the novel framework and methodology would be of benefit, especially in light of the researcher notes collected via field note commentary during the original study. The issue of direct

observation could be addressed, using differing degrees of covert observation (e.g. using individuals known to observed staff, keeping the aim of the study secret).

Secondly, the emergent theme of context and habituation offers many potential avenues for further research, using different settings to explore how these affect subsequent healthcare. Finally, as Study 2 found that current technologies possess capabilities to detect hand hygiene at activities that fall within the Elective category (linked to Moments 1, 4 and 5) there is the potential to use such innovations in research exploring this area. This potential is discussed further in Chapter 8 (see 8.5.) looking at a future system of measurement for hand hygiene.

7.8. Summary

Perceptions gathered from healthcare professionals in Study 2 supported the concept outlined in the Whitby et al. (2006) theory that hand hygiene intention is modified by trigger activity, be that Inherent or Elective. The results of the observations carried out in Study 3 (see 7.3.) supported this proposition, and found that hand hygiene was carried out significantly more at activities categorised as Inherent rather than Elective.

Chapter 8

Discussing Measurement of Hand Hygiene in Healthcare: Towards a Future System

8. Introduction

This chapter discusses the results of each of the three studies carried out as part of the main case study, and determines their contribution to answering the research question. Unifying themes across the studies are extracted for wider discussion to form recommendations on the future of hand hygiene measurement for the healthcare and technology settings, and the infection prevention community. Limitations of the case study conducted are presented along with the potential future scope for research within this field.

8.1. Objective of the Case Study

The research question asked: *What is the importance of Domain Knowledge and Human Behaviour for the development of successful Quality Audit Processes and (associated) Technologies?*

A mixed methods approach allowed both qualitative and quantitative methods to be applied, using three separate studies generating their own outputs on the route to answering the main research question (Figure 8-1).

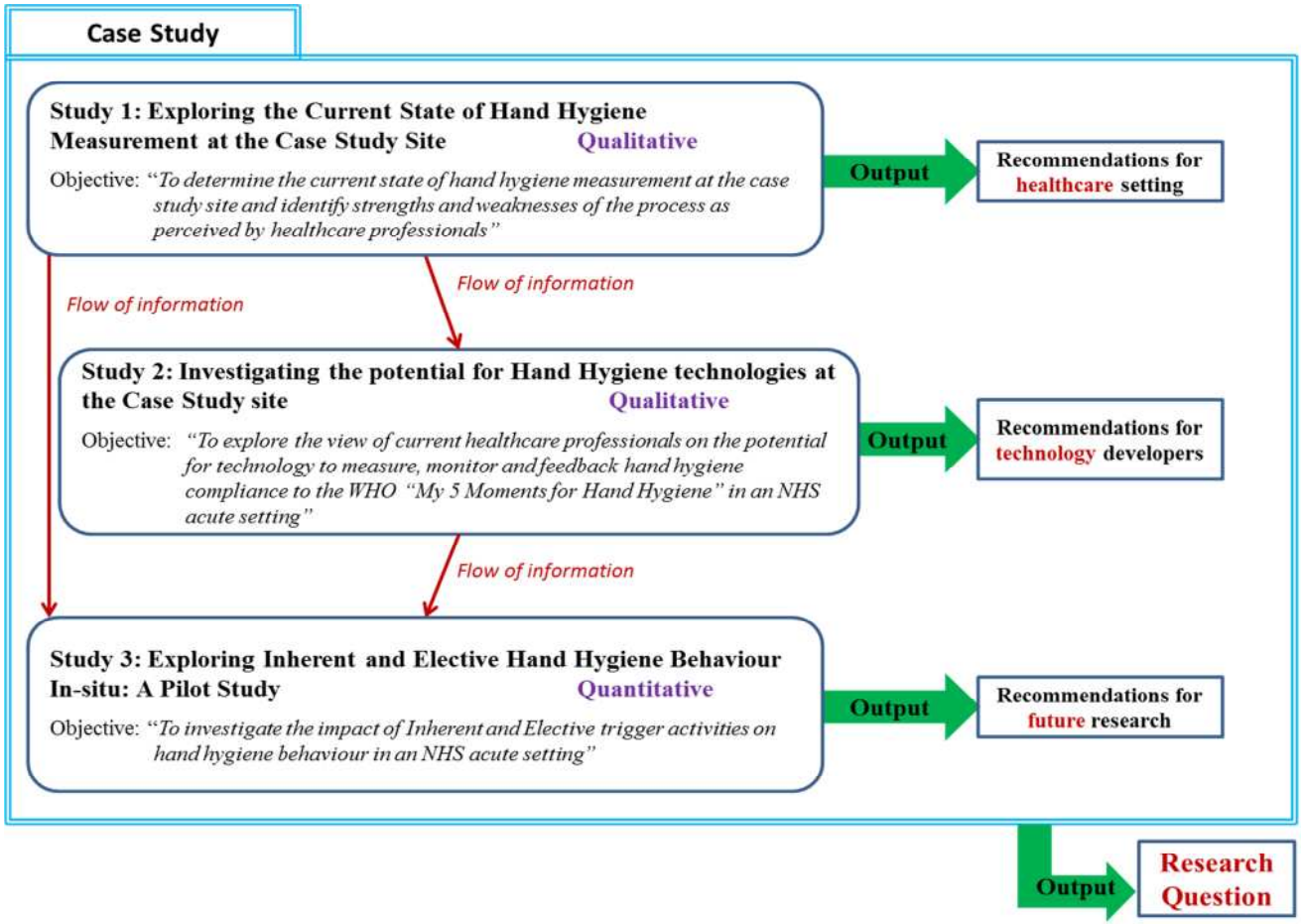

Case Study
Study 1: Exploring the Current State of Hand Hygiene Measurement at the Case Study Site
Qualitative
Objective: "To determine the current state of hand hygiene measurement at the case study site and identify strengths and weaknesses of the process as perceived by healthcare professionals"
Output
Recommendations for healthcare setting
Flow of information
Flow of information
Study 2: Investigating the potential for Hand Hygiene technologies at the Case Study site
Qualitative
Objective: "To explore the view of current healthcare professionals on the potential for technology to measure, monitor and feedback hand hygiene compliance to the WHO "My 5 Moments for Hand Hygiene" in an NHS acute setting"
Output
Recommendations for technology developers
Flow of information
Study 3: Exploring Inherent and Elective Hand Hygiene Behaviour In-situ: A Pilot Study
Quantitative
Objective: "To investigate the impact of Inherent and Elective trigger activities on hand hygiene behaviour in an NHS acute setting"
Output
Recommendations for future research
Output
Research Question

Figure 8-1: The mixed methods case study structure, consisting of three separate studies each contributing independent outputs feeding into the main output for the research question

The next sections outline the main findings of each of these studies, assessing how each contribute to answering this main research question.

8.2. Study 1: Establishing Domain Knowledge

8.2.1. Overview of findings

A series of structured interviews and participatory observation sessions with healthcare professionals from three defined groups characterised Study 1. Each group was established based on the differing roles and responsibilities existing within the current state of hand hygiene measurement (Audit Process Involvement, API, see 5.1.3.). Participants were drawn from a range of settings within the case study site. This system allowed the five pre-determined study aims to be achieved, resulting in a visual representation of the current state (Figure 8-2). This representation was validated through member checking by participants with roles in the audit process.

Thematic coding resulted in three emergent themes:

1. Incomplete Feedback Loops/Lack of Clarity with regard to Feedback
2. Lack of Synergy between Training and Feedback
3. Data Accuracy

These themes allowed discussion of the healthcare professionals perceived causes of burden when considering hand hygiene measurement, which were then explored for improvement recommendations.

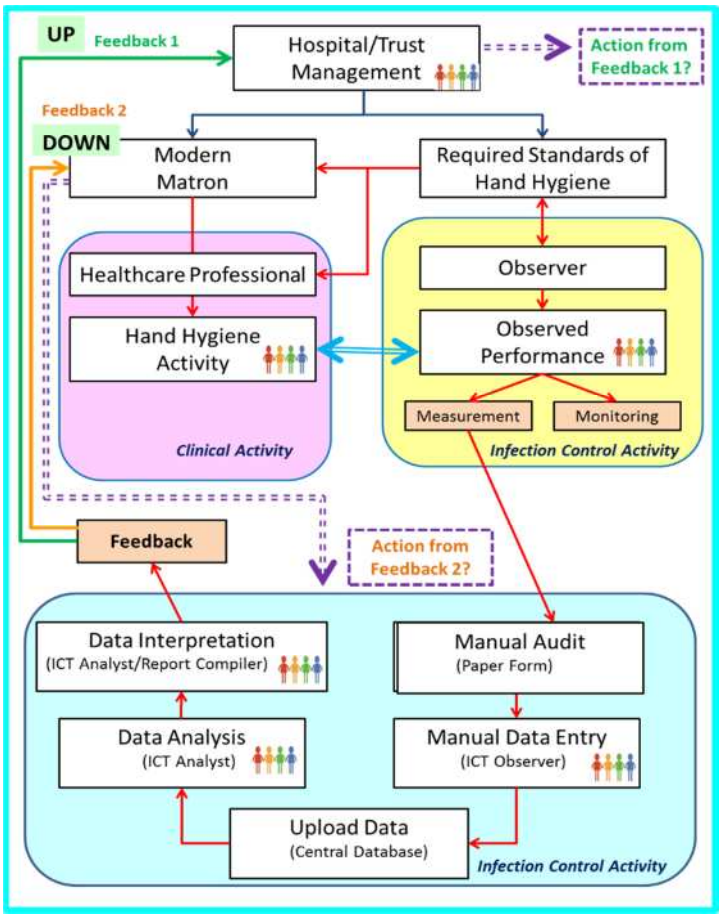


Figure 8-2: New Current State Map: Visual representation of the current state of hand hygiene measurement at case study site, an output of Study 1

The New Current State Map (Figure 8-2) was generated using input from all API groups included in the study. It allowed feedback loops, identified by participants as a weakness in the current process, to be demonstrated. Participants voiced a key issue of failing to close the loop across different areas of the process:

A further weakness attributed to feedback, that of disconnect between training and measurement criteria, emerged both through interviews and access to training sessions. Its effects appeared to be felt keenly by participants:

Combined these two weaknesses led to a perception held by participants that hand hygiene compliance data generated through the current measurement process at the case study site was often meaningless.

Despite the finding that auditing tools are specifically being designed for, and used, within the field of hand hygiene measurement, if left ignored this issue of meaning may result in such tools failing to deliver on their potential or purpose. Measurement through auditing is often an integral part of Quality Management (QM). Meaningful data, as discussed previously, has great importance in enabling a successful QM approach (Robbins, 2005). In discussion of the findings of Study 1the work of Hysong et al. (2006) was examined to produce an adaptation of their model of actionable feedback. This term is seen as interchangeable with meaningful data. This adaptation (Figure 8-3) was proposed as a potential framework to move from the current state of measurement, with its perceived weaknesses and frustrations, towards a future state where data generated for feedback could be perceived as meaningful.

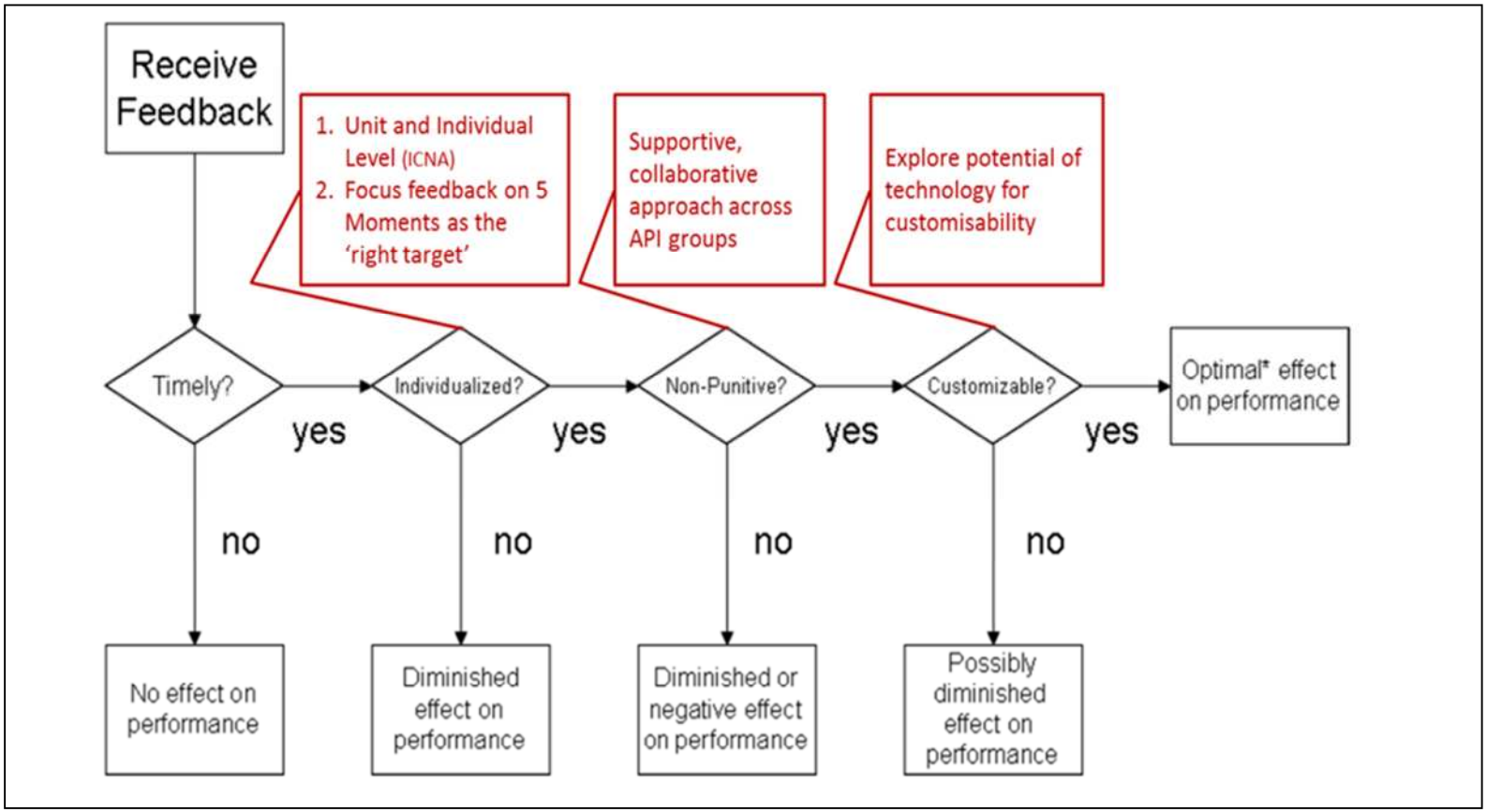


Figure 8-3: Adaption of Hysong et al. (2006) Model of Actionable Feedback, proposed as a working model for supporting the development of a new feedback process at the case study site, an output of Study 1

Such a model could be used to assess future proposed measurement tools to ensure they could provide meaningful data to each group within the audit process.

8.2.2. Contribution to Research Question

Study 1 addressed the issue of establishing "What is Domain Knowledge?" through an examination of the domain (the current state). It produced a visual representation (New Current State Map) allowing the current knowledge of those involved in this domain to be explored. This exploration uncovered underlying weaknesses in the current process of hand hygiene measurement at the case study site. Conducting the study and accessing domain knowledge via exploring the current process of measurement proposed the importance of meaningful data. This allowed a working model for variables required to develop an improved future state for feedback to be proposed (Figure 8-3).

Explicit domain knowledge was also gathered relating to required standards of hand hygiene and training objectives at the case study site. These national and global guidelines (Ayliffe technique, WHO 5 Moments) have already been established as key requirements for effective hand hygiene (RCN, 2012; Sax et al., 2009). Their presence at the case study site strengthens the argument for their incorporation into potential future processes for measuring hand hygiene compliance, as they are recognised standards already providing meaning to healthcare professionals. Disconnect between training objectives and measurement feedback was identified by participants as a weakness of the existing process. Feedback data was seen to bear no meaningful relation to what they were being taught. The inclusion of existing and recognised training objectives (WHO 5 Moments), identified through exploring the domain, would

remove the potential of this disconnect occurring again in a proposed future state. Thus for the case study site the recently launched (2011) IPS QIT tools[19] offer a potential replacement for the existing ICNA tool, as they contain a "Hand Hygiene Observation Tool" directly linked to the WHO 5 Moments. Developed following feedback (IPS, 2008) based on usage of their ICNA (2004) tools the QIT range have a much stronger link to QM, and the integration of data collection into a wider process of improvement:

> …*focus within quality improvement, on systems thinking, reliability, testing changes, and measurement has prompted the Infection Prevention Society to move away from traditional 'audit tools' and develop this suite of Quality Improvement Tools.* (IPS, 2011, pp. 4)

Use of the IPS QIT Hand Hygiene Observation Tool would allow manual means of hand hygiene measurement, similar to the current process. However it would provide data specifically related to existing training themes (WHO 5 Moments), satisfying identified requirements of both data collectors and recipients.

8.3. Study 2: Importance of Domain Knowledge

8.3.1. Overview of findings

In order to understand how technology might help with the required measurement standards at the case study site, existing innovations were reviewed and discussed with relevant healthcare professionals.

Two structured literature reviews revealed examples and capabilities of current technologies purporting to measure hand hygiene within healthcare. Their

[19] Developed with Royal Free and University College London Medical School Wales (McAteer et al., 2009), and the National Patient Safety Agency 'clean**your**hands' team.

capabilities were further examined through the development and application of a Fit For Purpose (FFP) matrix (Figure 3-3, Chapter 3). This revealed none possess the ability to detect all of the WHO 5 Moments. These findings formed the basis of structured interviews with participants from the three groups involved in the current process of measurement, to gather their perceptions as to the potential for such innovations within their workplace. The selection of methods resulted in all five study aims being achieved, providing an insight into the current availability and capabilities of technologies for measuring hand hygiene.

Analysis of existing data, combined with targeted interview probes, investigated whether specific areas of hand hygiene measurement or compliance were perceived to be more difficult to achieve than others. The rationale was to explore whether technology may be of potential benefit in such areas. Whilst the discussion surrounding this issue in relation to the current process of measurement at the case study site (i.e. ICNA tool), provided mixed results, greater clarity emerged in relation to the WHO 5 Moments. Moment 5 *After Touching Patient Surroundings* was highlighted as being most likely to be missed or considered difficult to perform or audit.

Such a finding suggests that mechanisms to remind or prompt hand hygiene, as found in 5 of the 19 technologies identified through the FFP literature review, may be of benefit (Appendix 2b). However, participant reactions stemming from being shown examples of current technologies suggested that prompting may have limited effect.

In-depth analysis of the participants' reactions to the technologies highlighted two broad themes, labelled as "Interest in potential" and "Concerns about technology".

Whilst the participants involved in the study were interested in the potential for technology to aid them with the task of hand hygiene measurement, and positively commented on some design aspects, their comments were not without concern. Included in these concerns was the effect of habituation and over-reliance on technology, whereby participants perceived that any benefits of prompting technologies may wear off over time, and could leave staff members vulnerable to no longer being able to act without external cues. There were also concerns with regard to the use of data and how this may affect engagement. Above all concern was raised about the FFP of current technologies, not only with relation to being able to detect the WHO 5 Moments, but also on unit and wider, organisational based factors.

8.3.2. Contribution to Research Question

Having explored the domain through mapping the existing audit process using the knowledge of the healthcare professionals involved (Study 1), Study 2 was able to assess the FFP of hand hygiene technologies against a domain specific backdrop. Technologies were not only assessed using the bespoke FFP matrix, but perceptions of FFP from those with domain knowledge (case study site healthcare professionals) were also sought.

Study 1suggested the development of a measurement process including the WHO 5 Moments may overcome the weaknesses identified with the current state. The FFP matrix identified that no current technologies could detect all of the WHO 5 Moments. However involvement of the participants in Study 2 uncovered that they did not feel this would necessarily be a barrier to the use of technologies within a measurement process. Participants were interested in the potential

capabilities of technologies to provide feedback on specific Moments identified (i.e. 1, 4 and 5), with the theme of meaningful data for self-improvement being prominent.

For technology developers the importance of considering domain knowledge can also be seen through the issues raised regarding concern over technology. These included ability to detect context, assess technique and practical and financial viability. Participants were particularly critical of the technology example (see Figure A-2, Appendix 2a) which appeared to have been developed with no consideration of the meaning behind the data being collected (Table 6-18).Participants echoed thoughts in existing literature (Boscart et al., 2008), showing enthusiasm for the potential of new innovations for hand hygiene. Whilst literature focusing on this aspect of FFP is scarce, sources from the wider healthcare field support the concept that healthcare professionals are open to technology, as long as it is seen to possess perceived usefulness (Li and Calantone, 1998; Davis, 1986).

The Technology Acceptance Model (TAM; Davis, 1989) argues that the involvement of end-users (healthcare professionals) in the development of technology for their own use increases its perceived usefulness. This reduces the likelihood of it being rejected when installed, and increases the likelihood of it being FFP. Furthermore, the TAM predicts that once individuals are made aware that a piece of technology has been developed with input from peers (someone who does the same/similar work) they also rate it higher on scales of perceived usefulness. Therefore they too are less likely to reject it and more likely to find it FFP. The implication for technology developers is that exploration of the domain

(here, hand hygiene measurement), including involvement of end-users, is likely to increase resultant innovations being perceived as FFP. At the case study site issues such as the lack of relevance of hand hygiene measurement at door entry/exit and capabilities to measure individual aspects of Patient care (currently manually observed) would no doubt be high on the end-user perceived usefulness list. To ensure FFP of future innovations the proposed adaptation of the Human-Tech Ladder (Vicente, 2006) for hand hygiene technologies may offer a starting point for discussions between technology developers and healthcare providers

With respect to technology limitations, the interviews revealed that healthcare professionals felt differently about the individual WHO Moments, with Moments 2 and 3 seen as already being carried out automatically. Therefore it is proposed that activities encapsulated by Moments 2 and 3 may be less likely to need the benefits of technology (monitoring feedback/prompting), than those covered by the remaining Moments. By assessing the FFP of hand hygiene technologies with the inclusion of views from those within the domain, it was possible to reach a greater understanding of perceived benefits and limitations of such innovations. This was particularly useful in terms of uncovering discrepancies between held beliefs of these healthcare professionals and stored data regarding hand hygiene compliance. This discrepancy was in line with existing literature, whereby inaccuracies are found in self-reported hand hygiene rates (higher than observed rates; Elridge et al., 2006;Moret et al., 2004; Tibballs, 1996). Similarly, behavioural models for hand hygiene have had greater success in predicting intention to perform hand hygiene, as opposed to actual behaviour, indicating an effect of additional variables (Jenner et al., 2002).

Such findings, with associated supporting literature, helped form the aims of Study 3.

8.4. Study 3: Impact of Human Behaviour

8.4.1. Overview of findings

A series of structured observations allowed a novel framework to be developed following in-situ observations at the case study site, investigating whether the category of clinical activity affected likelihood of healthcare professionals performing hand hygiene. Clinical activities were separated into Inherent or Elective categories, based on original definitions from Whitby et al. (2006). Healthcare professionals validated these categorisations, and an initial framework was developed to guide the observations. Of the 20 pairs of clinical activities analysed (one Inherent, one Elective, randomly selected for each participant), thirteen showed hand hygiene being performed for Inherent triggers but not for Elective triggers, whilst seven showed hand hygiene being performed universally, for both Inherent and Elective clinical activities. This difference in behaviour was found to be significant: χ^2 (df 1) 11.077, p=<0.001. This indicated type of clinical activity influences likelihood of performing hand hygiene. The novel approach of this study indicated for the first time within an NHS setting that hand hygiene was *less* likely when activities were categorised as Elective rather than Inherent.

8.4.2. Contribution to Research Question

Whilst Studies 1 and 2 addressed domain knowledge, Study 3 was designed to address the concept of human behaviour. Based on existing literature and findings from Study 2, the study set out to provide empirical data to support the

notion that different clinical activities affect the likelihood of hand hygiene being performed. Healthcare professionals voiced a perception that some activities (which would be classified as WHO Moment 2 and 3 opportunities) would be much less likely to be missed than others, in keeping with existing literature (Whitby et al., 2006). However, as self-reported hand hygiene has been shown to have limited reliability (Elridge et al., 2006), combined with difficulties linking hand hygiene intention and actual behaviour (see 3.4.), the objective of Study 3 was to observe actual hand hygiene behaviour in response to differing clinical activities.

The finding that hand hygiene was more likely for Inherent clinical activities than Elective clinical activities supports the view than human behaviour influences hand hygiene. The implications for hand hygiene measurement, in light of the findings from Study 2 regarding technology limitations, suggest that a dual-method approach may be of most use going forwards: building on the natural strengths of human behaviour and the current benefits of available technology.

It is here that the discussion now leads, focussing on a proposed system of measurement for hand hygiene involving both technology and direct observation. This can allow meaningful data to be fed back to healthcare professionals concerning compliance rates at each of the globally recognised WHO 5 Moments.

8.5. Answering the Research Question: A Future System of Measurement

Findings from this research suggest that considering both domain knowledge and human behaviour would be beneficial when developing new quality audit processes, especially if they are to incorporate a technological element.

Failure to explore the domain may lead to processes and/or technologies which function and produce data, but which, upon closer inspection, are failing to produce the vital meaning alongside it.

Hand hygiene is not a unique case in suffering from the phenomenon of data which is perceived to be meaningless, either at the case study site, within the healthcare field, or from a wider organisational scope. Within healthcare Powell et al. (2010) highlight lack of integration between use of auditing and other TQM tools. Taken in isolation, collection of data, however systematic, will ultimately provide little assistance to those trying to achieve and sustain overall change, with Bridges (2003) highlighting the need for involvement of healthcare professionals. During the interview process for Study 1, the relatively newly introduced Safety Thermometer (Harm Free Care 2011-2013) was raised as an example of more required auditing without overall clarity as to what the resultant data actually meant in terms of practice change for those responsible for Patient care.

The novel tool was seen to allow visibility on data regarding critical Patient safety issues, perceived as an advantage over existing, independent measures:

> *…traditionally, in nursing, and in medicine generally, we've looked at these harms in silos, so you'd look at, you'd have a group that - which we have in our Trust, - we have a group that look at Pressure Ulcers, we have a group that look at Falls, we have a group that looks at Saving Lives which is all stuff around infection, and then there's other groups for VTE. But they don't really talk to each other…* (AS)

However, it was unclear (albeit the implementation was at an early stage) how the disseminated data would aid front-line staff understand how to change their ward-based activities:

> …*firstly we need to make sure people know to read the KPIs* [Key Performance Indicators], *and secondly it's a case of translating a percentage change into* 'well what does that mean to me today?', 'what do I need to do differently and when?'….*and that's probably the bit that gets missed out of a lot of these data collection exercises…* (AS)

As outlined by the Department of Health, the initiative is intended only as an indicator, rather than a standalone, singular measurement tool. Therefore additional resources would be expected to address such issues of required practice change, including re-training where necessary:

> …*NHS Safety thermometer takes only minimum sets of data that help to signal where individuals, teams and organisations might need to focus more detailed measurement, training and improvement…*
>
> (DoH, Chief Nursing Officer Bulletin, October 2012)

Critical to the success of the new approach, discussed with those responsible for the introduction and management, was perceived to be the integration of the Safety Thermometer data with routine ward objectives. This was in addition to training and education, to ensure that the monthly KPI data would be recognised and easily interpreted by staff of all levels. Such a view stems from the successful trial of the "Productive Ward" approach (Smith and Rudd, 2010), incorporating three NHS Institute for Innovation and Improvement modules. The Productive Ward included the involvement of staff and strong feedback loops of meaningful data as core elements. Of particular relevance to the discussion here was the module *Knowing How You Are Doing*. This had a focus on monthly KPI generation, which provided data for ward discussions and were found to generate a sense of purpose within the ward team (Smith and Rudd, 2010). However, the extent to which this has been achieved with the Patient Safety Thermometer is yet to be seen. When the topic was independently raised by one of the GoD it was

clear that the meaning behind its objective and potential benefit had perhaps yet to be fully communicated:

> *…if you look at everything that a Modern Matron and a Ward Manager are expected to fill in on a Monthly basis, you'll see why they struggle…there are the Key Performance Indicators…they do a thing now called the Thermometer…it's all around Nursing care. Catheter Audits, Peripheral Cannula, Hand Hygiene, they just keep intro…and they've got to fill these in every month – the Ward Managers – on top of everything else…!..*

Within manufacturing, the traditional home of KPI usage, PDSA cycles and other QM tools, meaning behind generated data is not necessarily shared organisation wide. A review of the use of KPI measures within the construction industry (Beatham et al., 2004) found that whilst they had been widely adopted, they were used predominantly as historical markers, to assess performance and market the industry against pre-determined benchmarks. However, KPIs provided no opportunity for organisations to react and action required change. Due to this, KPI data was found to be used at a very high level within the industry as a whole, rather than as a tool to influence managerial decisions.

Hoyles et al. (2007) emphasis the need for recognition of context and meaning when using mathematical and/or statistical data to communicate meaning within organisations. They explain that, as well as drawing inferences from data, individuals impose their own knowledge and interpretation onto it to explain meaning. Thus, within a clinical setting, knowledge of the context from which the data is collected may allow greater meaning to be felt by the individual, rather than being presented with purely numerical or graphical information.

The implication is that involvement of those throughout the domain of measurement should be secured to elicit meaning, using contextual variables to ensure relevance and validity. Within the field of hand hygiene this could include consideration of contextual variables known to influence hand hygiene rates (e.g. ward setting, staffing levels) when comparing baselines. Use of such considerations have been seen to be applied in calculations underpinning baseline algorithms used in some electronic measurement systems (e.g. DebMed, 2013).

Literature supports the view that culture change, including bottom-up involvement with top-down support is required to ensure QM approaches such as TQM and Lean are successful (Powell et al., 2009; Walley and Gowland, 2004). However the same sources also document that healthcare is a particularly difficult culture within which to achieve such change. However, the WHO 5 Moments offer an opportunity to provide meaning to healthcare professionals on two fronts, which may explain why adoption has been so successful (Sax et al., 2012).

Firstly, usage of measurement tools based on the WHO 5 Moments can provide quantitative data about healthcare professional performance at each of these Moments independently, allowing generation of routine KPIs. As discussed, such markers have been shown to aid discussion within a ward based environment, providing a sense of purpose to clinical teams (Smith and Rudd, 2010). KPIs can also be used to communicate performance succinctly as required (interdepartmental and Trust level meetings). In addition, however, these Moments can also provide qualitative information to healthcare professionals, through their direct relation to education and training content. Therefore a fall in collected hand hygiene performance data at a particular Moment can instantly be

related to specific Patient care activities. These activities can be then become the subject of targeted discussion, and, if deemed necessary, intervention. Further, those from which the data has been collected can also add contextual information regarding perceived barriers felt to prevent or hinder hand hygiene at specific activities categorised under relevant WHO Moments, rather than just hand hygiene overall. Breaking down barriers may make required actions appear, and be, more manageable to achieve and overcome (Womack and Jones, 2003).

Understanding human behaviour offers the opportunity to capitalise and compensate on strengths and weaknesses. This is particularly useful where known limitations in technology may exist. This is the case in the field of hand hygiene technologies, as assessed by the FFP (Chapter 3, Chapter 6). Study 3 established that hand hygiene is more likely in response to some activities than others, and further analysis of these activities (Inherent) appears to suggest a link with WHO Moments 2 and 3. Currently activities relating to these Moments cannot be detected by hand hygiene technologies, thus data about healthcare professional compliance cannot be recorded and fed back using new innovations. Existing technologies can, however, detect and provide feedback (both stored and real-time) about Moments 1, 4 and 5, which appear to reflect activities classified as Elective, and less likely to result in hand hygiene.

Therefore a future system of measurement may consider human behaviour and technology development as part of a supportive relationship to capture and produce meaningful data. Moments 1, 4 and 5 may be considered the focus for technology developers, allowing benefits of technology to feature in a future state of hand hygiene measurement. Such benefits include an ability to monitor *behind*

the curtain. This can be a problem for the direct observer, often unable to view Patient care activities (van de Mortel and Murgo, 2006). Technologies (once passed by hospital regulators) are without such restraints, thus data collection can continue undisturbed. Cheng et al. (2011) suggest that technology may significantly reduce observation effects. In their comparison of electronic and manual surveillance, measured compliance was found to be 2.8 times higher for manual observation sessions than electronic surveillance only sessions, suggesting a Hawthorne effect. Boyce (2011) comments Moments 1, 4 and 5 may be responsible for approximately 80% of all HHO within clinical care. Use of technology to capture increased levels of meaningful data from these Moments may represent a significant benefit to those aiming to improve hand hygiene overall. Should technology be successfully introduced direct observation may be concentrated on capturing hand hygiene data at Moments 2 and 3, potentially reducing the current time burden of manual auditing.

This may be of significant advantage when considering the high level of *N/A* responses recorded at the case study site. Certainly some of these, for example 32g *After leaving an isolation room* (*N/A*= 64%), could potentially be monitored by technology. Others would perhaps need a more sensitive, manual, approach e.g. 32e *Prior to handling food* (*N/A*=87%). No specific examples can be given for WHO 5 Moments at the case study site, but previous similarities between ICNA points and WHO 5 Moments indicate the benefit of a new technology/manual approach. ICNA point 32c *Prior to clinical procedures* (linked to WHO Moment 1) was seen to have the lowest level of compliance, and also generated N/A=72%. Additional measurement would likely be suggested, to identify potential barriers to hand hygiene at this specific point. Previous

discussions surrounding this category (see 5.4.3.b.ii) indicate that clinical procedures may include activities relating to more than one WHO Moment. These include Moment 4 (*After Touching a Patient)* and Moment 2 (*Before Clean/Aseptic Technique*). Therefore both manual and technological measurement would be an option for those considering monitoring the effects of an intervention designed to improve performance in this area.

Interestingly the majority of participants (11/12) providing an answer to the *Ideal Scenario* interview prompt (Appendix 3d) used technology when describing their vision, including cameras, CCTV systems, mist sprays and Patient alert systems

This suggested both an interest, and perhaps awareness, of such innovations within the domain of hand hygiene measurement. Additionally, the participants were keen to emphasise that many of these ideas would be unfeasible, predominantly for ethical reasons, including Patient and staff confidentiality. Such awareness, to weigh up the potential benefits of technological innovations with practical issues of feasibility, is also necessary to consider with regard to any proposed future system of measurement.

8.5.1. Feasibility Issues

As well as FFP a clear concern for technology use stemmed from how data would be used, with themes of punishment and reprisals raised by participants. In parallel, discussion of the generation of meaningful data for a future state through adaptation of the Hysong et al. (2006) model highlighted a need for a non-punitive culture. Predicted financial implications of implementing technology into every ward of every hospital are a key consideration, although details regarding such

matters are scarce (Boyce, 2011). Figures are typically only available for systems/innovations on the market, and often system costs are calculated on a bespoke basis. Combined, such concerns represent significant issues of feasibility that must be addressed. This is particularly important when considering discussed matters of potential habituation or over-use of technology, which may further limit the effectiveness of attempted wide-scale implementation.

A potential solution to successfully incorporating technology into hand hygiene measurement, whilst reducing the prohibitive financial burden and issues of habituation and over-use, could be to consider its role in education. This is discussed in full as part of Future Work (see 8.7.). In brief, the application of technology may be seen as having the potential to gather data on the performance of healthcare professionals at specific Moments (1, 4 and/or 5) during interventions designed to identify training targets. As part of a PDSA cycle (Figure 8-4), and in combination with manual auditing tools to collect data for Moments 2 and 3, data would be studied for trends in performance. These could be used to highlight areas requiring additional training and further educational opportunities.

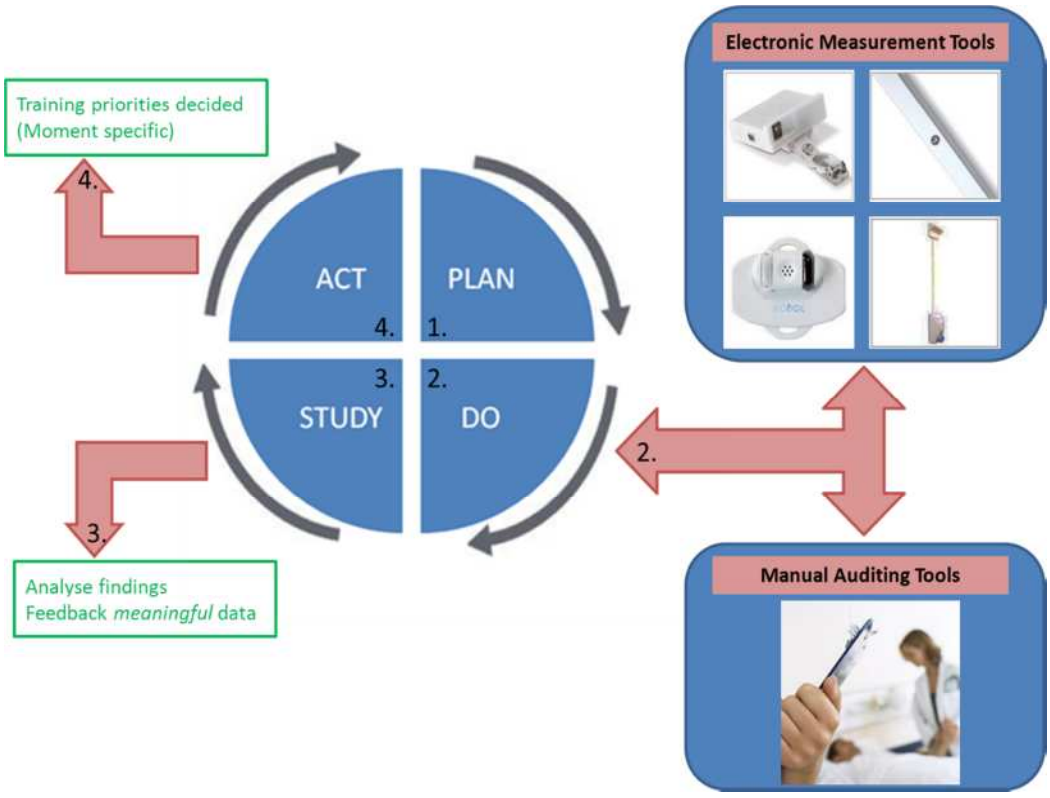


Figure 8-4: Potential PDSA framework highlighting opportunities for both technology and manual auditing to provide data regarding training priorities

Domain specific information about performance has been highlighted by the WHO (2009d) as a positive concept to focus attention on delivered education content:

> *….evaluation and feedback especially about local compliance rates and results from the knowledge test (by raising awareness of existing gaps and defective practices), trigger attention to the concepts targeted by education.*
>
> (WHO, 2009d, pp.16)

The proposed framework (Figure 8-4) offers the opportunity to do this at unit, and potentially, individual level, based on the acceptance of the healthcare professionals involved. This framework also works favourably with regard to the adapted Hysong et al. (2006) model (Figure 5-15), offering the potential for timely, individualised, non-punitive and customisable feedback data.

8.6. Limitations

The current research employed a case study approach, employing a single NHS Trust as the setting for all three empirical studies. This leads to a limitation of scope, however this has been mitigated to some extent by the inclusion of recognised global guidelines (WHO 5 Moments) allowing the potential for research replication and thematic generalisation in other healthcare settings. Further, the nature of aspects of the research, to focus on the importance of domain knowledge, encourages replication in other domains using methods outlined in the research. This would allow the benefits of understanding the current state and underlying weaknesses to be gained by other healthcare settings.

Similarly, in relation to scope, whilst a number of interesting themes emerged during the research, particularly during interactions with healthcare professionals at the case study site, not all could be developed for inclusion at this stage. Decisions on which themes to carry forward were made using links established through axial coding (Studies 1 and 2), and resource limitations (Study 3).

In particular two themes raised by healthcare professionals in this research would have been very interesting to pursue further, as they are currently prominent in literature and debate within the wider field of hand hygiene. These themes were: i) the over-use of gloves, and ii) personal responsibility.

In brief, Wilson et al. (2013) highlight the overuse of gloves, characterised by usage during clinical duties posing low risk of cross-contamination (i.e. minimal risk of blood/bodily fluid contact). This echoed the emergent theme from the current research.

Personal responsibility, the concept of poor hand hygiene compliance ultimately leading to reprimands and reprisals, as would be the case with other medical errors, is an emergent topic in the field. A non-punitive, supportive culture is the recommended approach (WHO, 2009), and fear over use of the data for reprisals was found to be a theme when discussing the potential for technology. However, it is understood, as discussed at ICPIC 2013 (Hand Hygiene session with Pittet, Sax, Thursday 27th June) that targeted behaviour change is necessary. This may often involve addressing individuals who continually fail to perform hand hygiene. Failure to address such issues may alienate other healthcare professionals, prompting questions about the relevance and effort behind new interventions. Participants raised this issue with relation to how non-response to technology prompts (e.g. flashing red lights) would be handled.

Continuous demonstrations of no repercussions for (e.g.) ignoring a red light may lead to a reduction in effect of the desired prompt for other healthcare professionals using the innovation.

It is acknowledged that small samples were used for both Studies 1 and 2, and healthcare professionals were purposefully selected, which can lead to criticisms of selection bias. However, this strategy was important to the objective of the research, and was used advantageously: "Knowledge gatekeepers" were used to identify meaningful cases (Uwe, 2006). Study 3, whilst using a sample size calculated to produce a strong power ($\alpha = 0.05$, power = 0.9), is limited by potential bias stemming from its observational nature. Though efforts were taken to mediate such effects, field note commentary revealed behaviours suggesting that some participants still showed heighted awareness during the data collection

period (engaging with the observer, using sinks located closer to the observer than the activity performed). For future replications or extensions of this work further consideration of how to overcome this issue would be required, including the potential of using a degree of covert observation, despite acknowledged limitations (risk of future distrust, WHO, 2009).

8.7. Future work

The current work provides scope for development, firstly to further explore promising behavioural themes developed during the pilot study work (Study 3), and secondly to consider the impact of such themes on the related area of hand hygiene education. Both could employ the benefits of emerging technologies.

a. Inherent and Elective Hand Hygiene: WHO 5 Moments

Bahal et al.(2007) proposed the conceptual "splitting" of the WHO 5 Moments based upon human behaviour, the idea that activities may be categorised into Inherent or Elective:

> *If we assume that the higher rates in post-contact hand hygiene is the result of HCWs considering themselves to have been contaminated then our observations concur with the recent premise (Whitby et al, 2006) that HCWs subconsciously compartmentalise all hand hygiene opportunities into two responses: inherent hand hygiene practices (associated with dirty hands or perceived contaminated hands), which will take precedence over opportunities associated with elected practices (where hands look and feel clean) (Whitby et al, 2006).* (pp. 27)

In their approach, a before/after conceptual split is used, based on a belief that the self-protection component of Inherent hand hygiene would be evident *after* contact with Patients, rather than *before*. Before contact with Patients would be

more closely related to the Elective component of hand hygiene. Extrapolated out this would allow Moments 1, 2 to be seen as *before* and Moments 3, 4 and 5 to be seen as *after* (Figure 8-5).

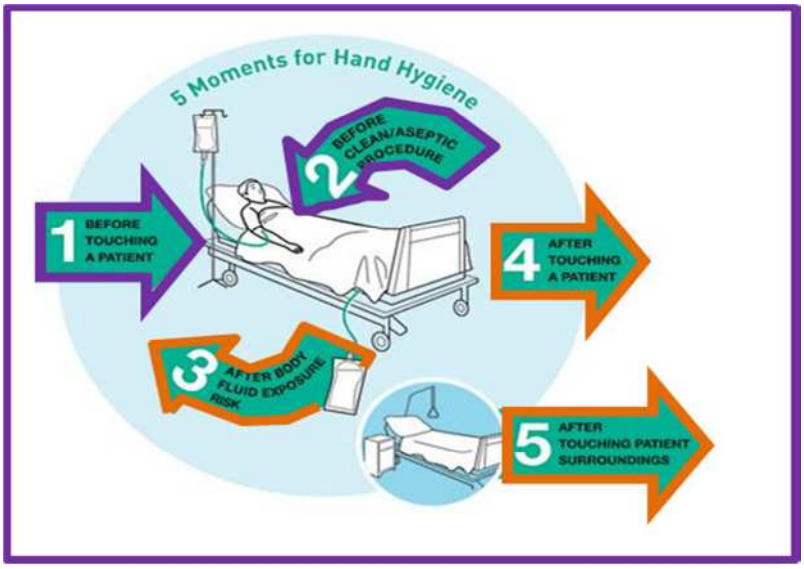


Figure 8-5: An adapted model of the WHO 5 Moments: The Bahal et al. (2007) "Split" (*Purple = Before (Elective), Orange= After (Inherent))*

Whilst such a split (Figure 8-5) has a logical basis, as data suggests a greater propensity for hand hygiene following Patient contact rather than prior (Erasmus et al., 2010), categorisation is complex. Whereas Moments 3 and 4 could be seen to link to Inherent hand hygiene, through hands being physically dirty, or feelings of emotional dirtiness or self-protection, inclusion of Moment 5 is less convincing. Study 2 participants perceived Moment 5 as most likely *not* to be performed, a notion supported by empirical data (Rossini et al., 2013; Grayson et al., 2011). Further, activities relating to Moment 5 (e.g. touching a Patient's bed) resulted in low hand hygiene during Study 3 observations (hand hygiene performed once out of six HHO). This is in marked contrast to activities related to Moment 3 (e.g. handling soiled linen, hand hygiene performed eight/nine HHO).

Due to the unlikely success of the aforementioned split, based solely on a before and after conceptualisation, the suggestion of the current research is to retain a focus on the influence of Inherent and Elective hand hygiene, yet to apply the split based on the outcomes of Study 3 (Figure **8-6**).

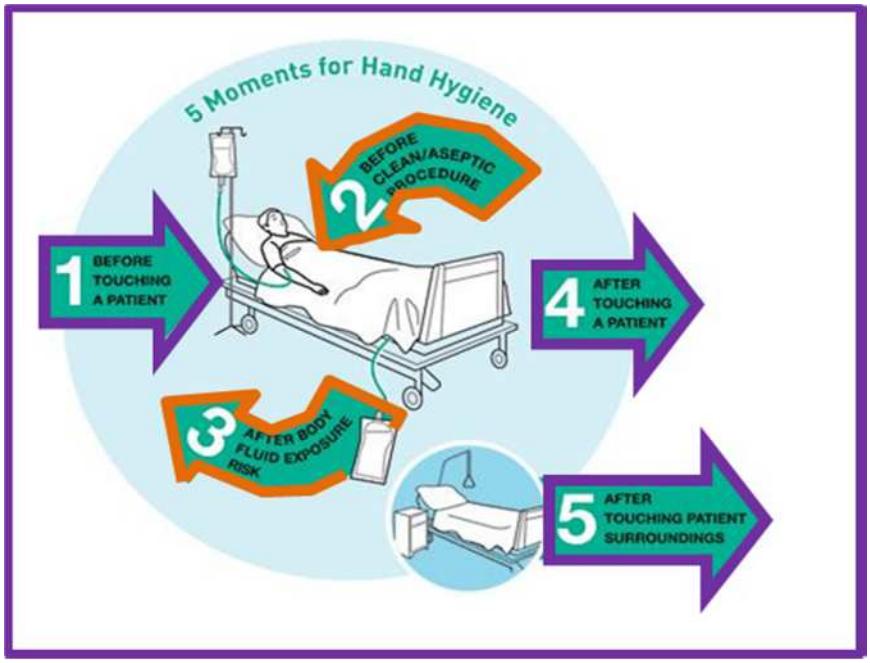


Figure 8-6: A new adaptation of the WHO 5 Moments: The Current Research "Split"(*Purple = Elective, Orange = Inherent)*

This work confirmed the views of participants in Study 2 regarding which activities would be more likely to trigger hand hygiene, and provides a starting point for future work. As a pilot study, Study 3 offers the opportunity for replication to further test the novel framework and method, including testing in a range of settings outside of the presented cardio-thoracic unit. Based on the "superman theory" of Nicol et al. (2009) (Chapter 7, pp.323) a future study is proposed comparing the effect of context on differences between Inherent and Elective hand hygiene triggers. According to the "superman theory" working in an environment with repeated exposure to activities which may be linked to Inherent triggers (e.g. a renal unit with multiple exposures to blood) may lead to

desensitisation. Therefore it may be expected that no difference between Inherent and Elective triggers would be found.

The suggested "split" of WHO 5 Moments (Figure **8-6**) can be investigated for feasibility using existing and future data, collected routinely by healthcare settings employed the WHO 5 Moments measurement tool. A future study, involving multiple sites, may seek to identify trends in hand hygiene data over the WHO 5 Moments. Based on the influence of Inherent and Elective behaviour, established in Study 3, should the split be appropriate higher levels of hand hygiene should be apparent at Moments 2 and 3, when compared Moments 1, 4 and 5.

b. Education and Training

As part of their Learning Principles, applicable to organisations including healthcare, Smith and Delahaye (1987) highlight the importance of meaningful material to successful education and training. They suggest individuals react with two unconscious questions when presented with new information:

(i) "Is the information valid when I compare it with my past experiences?"

(ii) "Will this information be useful to me in the immediate future?"

The implication of these questions is that for an individual to move from the known to a willingness to consider the unknown, information must be perceived to be readily useable by participants. The importance of meaningful data for feedback has already been established (Study 1) and the capabilities for technology to deliver such data has been discussed (Study 2), especially for WHO Moments 1, 4 and 5. In terms of the unconscious questions of Smith and Delahaye (1987), it can be envisaged that information relating to Inherent hand

hygiene, at Moments 2 and 3, will receive a positive reception to the first (*I would wash my hands if I had contact with bodily fluids*), but perhaps a negative reception to the second (*I do not need to be told this, I would do it automatically in the future*). Information relating to Elective hand hygiene, at Moments 1, 4 and 5 may generate a more mixed reaction. Individuals may find themselves in conflict, as the information they are being taught may be in opposition to past experiences (*I would not normally perform hand hygiene after touching furniture*). However, they may see that the information will be of use to them in the future if they understand it is the basis of Patient and personal safety within the environment they have chosen to work (*I understand that the environment can contain microorganisms that can transfer onto my hands*). Implications for these responses are discussed shortly in light of work by Robotham (2001).

Participant opinions (Study 2) and empirical data (Study 3) suggest recourse to hand hygiene at Moments 2 and 3 is more automatic. Resources to ensure healthcare professionals are aware of the need for hand hygiene at activities related to these Moments may not be as vital as for those at Moments 1, 4 and 5.

Such a suggestion, that education surrounding hand hygiene could be split depending on underlying behavioural drivers (Inherent, Elective), linked to associated WHO Moments, is not to suggest that the WHO 5 Moments should be practically split. They were developed from a user-centred standpoint (Sax et al., 2007) which has been shown to be successful in allowing individuals to visualise routines of Patient care, including both the Patient Zone and Healthcare Area. Deviation from this established concept is likely to be detrimental (Sax et al., 2012). However, it is acknowledged that attitudes to hand hygiene training are

often less than optimal, with an investigation into medical student education by Kaur et al. (2013a, b) reporting key findings including:

1. Medical students do not see hand hygiene as an important topic, seeing it as a boring topic to learn, and feeling it condescending to be told if they are not doing it correctly.
2. Medical educational experts believe students would benefit from more hand hygiene training but are unsure whether it should be taught in hospitals during clinical training, and believe students rate such training lower than other core medical concepts.

Such findings were echoed at the case study site. GoD noted that whilst annual hand hygiene training was mandatory, engaging healthcare professionals was difficult, especially those more senior in the clinical staff hierarchy. Difficulty obtaining doctor's attendance to hand hygiene training has been highlighted by the WHO (2009) during piloting of the WHO 5 Moments. Professional category has been shown to affect hand hygiene compliance (Erasmus et al., 2010; Allegranzi et al., 2009; WHO, 2009), and Kaur et al. (2013a, b) suggests that attitudes to hand hygiene may be formed early in the career of clinical staff. This may then be reinforced through role model effects (Lankford et al., 2003).

RoF and SoO participants in the current research provided examples of indifferent attitudes to hand hygiene training at the case study site, during the course of interviews conducted for Studies 1 and 2. Comments such as *Teaching me what I already know* and [It is telling me about] *Washing my hands when they have stuff on* support the findings of Kaur et al. (2013a, b) regarding a perception that hand hygiene training can be perceived as condescending. Similarly, as found by Kaur

et al. a senior medical healthcare professional noted their belief that hand hygiene training was of much greater relevance than other training they attended, yet felt it was being promoted less within clinical training than other medical concepts.

A future state of measurement, potentially incorporating technology, could seek to address indifferent attitudes to hand hygiene education through the generation of meaningful data, using the WHO 5 Moments as a framework. By recognising that individuals have an Inherent, automatic recourse to hand hygiene for some activities, which appear linked to WHO Moments 2 and 3, training programmes may be able to address head on the concept that they are telling individuals "what they already know". Nicol et al. (2009) concur that currently a predominant assumption in hand hygiene education is that the behaviour is a result of conscious deliberation, yet behavioural studies and theory, including that of Inherent and Elective, indicates a strong influence of unconscious, automatic drivers, based in well-established habitual behaviour.

Hand hygiene education may be able to utilise a conceptual split in the WHO 5 Moments, to overcome current issues regarding indifferent attitudes to hand hygiene training. Named here as the "Buckaroo hypothesis" the proposal for future work suggests that existing trends in attitudes towards hand hygiene training may come from perceptions that it solely focuses on what this research would classify as Inherent. Therefore, healthcare professionals have a perception that they are being trained on things that they would do automatically, leading to a rejection of *all* areas of hand hygiene education, despite much of the information being imparted being related to non-automatic, non-standard behaviours e.g. reasons for hand hygiene being necessary after environmental contact.

Thus the potential model for future education within this field is to work in partnership with healthcare professionals, acknowledging that whilst some hand hygiene may seem automatic (Inherent), other aspects (Elective) require specific training to understand and incorporate into a safe model of Patient care.

This proposed partnership with healthcare professionals can be seen to relate to the concept of andragogy (the teaching of adults), discussed within the domain of safety critical education by Robotham (2001). Whilst a topic too vast for thorough exploration here, a key element is the notion that adults, unlike children within education, bring with them life experience into training opportunities. This life experience may be liable, Robotham proposes, to lead participants to question and challenge provided information that does not match that amassed from previous experiences. This is similar to the unconscious questions previously proposed by Smith and Delahaye (1987) (pp. 356). It could be expected, therefore, that the topic of hand hygiene may be challenging to communicate, due to the noted heavy influence of community expectations and behaviour (Chapter 3: Part B). Required hand hygiene at times when it would not normally be applied in the community (e.g. after touching furniture), may incite challenges from those attending training. The proposed conceptual "split" of WHO 5 Moments (Figure **8-6**) may allow the potential for such conflict between training content and previous experiences to be anticipated and addressed head on by training hosts. Additional focus could be applied to activities which would not usually provoke hand hygiene (relating to Elective hand hygiene) to ensure healthcare professionals were aware of evidence underlying the need for hand hygiene at such moments (stemming from Sax et al., 2007). A novel way of providing this evidence may be the use of ATP swabbing of surfaces within the Patient

environment (Moment 5), or hands prior to touching a Patient (Moment 1), involving the healthcare professionals collecting direct evidence for the need for hand hygiene as part of their mandatory training. Such techniques, labelled "multi-sense learning" by Robotham, have been proposed as effective (Smith and Delahaye, 1987). ATP swabbing has been shown to generate enthusiasm and interest in hygiene data within an NHS setting (Reakes-Wells and Dawson, unpublished work in progress).

8.8. Chapter Summary

Generating knowledge about the specific domain can enable a concept of meaningful data to emerge within such a setting. This in turn could allow more effective auditing processes to be developed. Within hand hygiene, technologies exist to enable measurement, however limitations restrict them to partial fulfilment of required levels of auditing standards, with additional financial, moral and long-term use considerations. Nevertheless, when seen as tools to aid awareness of specific performance at individual moments of activity (based around WHO Moments 1, 4 and 5), within a structured PDSA framework (Figure 8-4), such innovations may offer a feasible educational and training tool. Short-term usage on a hospital unit to highlight areas of strength and weakness, followed by targeted education and intervention, with re-measurement at a later date may enable technology to be both financially viable for the healthcare setting, and maintain a fresh and novel character for the healthcare professionals involved.

Chapter 9

Measurement of Hand Hygiene in Healthcare: Conclusions

If you cannot measure it, you cannot improve it[20]

Lord Kelvin (Thomson, 1883)

9. Conclusion

The current research addressed the question *What is the importance of Domain Knowledge and Human Behaviour for the development of successful Quality Audit Processes and (associated) Technologies?* Concluding that both elements could be utilised to produce a more effective future state of measurement for hand hygiene.

9.1. The Importance of Domain Knowledge

Domain knowledge, defined as the harnessing of tacit understanding and awareness from those involved in the process being investigated, was explored by conducting Study 1. The use of purpose built figures (API Diagram and New Current State Map, Figure 5-3, Figure 5-9, Figure 5-10) allowed domain knowledge to be developed through ensuring involvement from groups throughout the current measurement process, and themes generated from its use to be visually represented.

Such representation brought clarity to perceived weaknesses held by healthcare professionals regarding the current state of hand hygiene measurement at the case

[20] These words are often attributed to Lord Kelvin, although the full quote reads:
"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be".
Whilst the quote infers superiority for numerical measurement, which is opposed to the viewpoint of the current research, which attests to the value of both qualitative and quantitative data, the fundamental need for valid measurement as a starting point to monitor improvement remains.

study site. Two primary themes, regarding a lack of clarity with regard to feedback and a lack of synergy between training and measurement were compounded by issues surrounding data accuracy. Combined these weaknesses led the majority of Study 1 participants to conclude that the data produced by their current state of hand hygiene measurement was meaningless. This was in spite of such measurement being routinely collected, using recognised, standardised tools, and providing levels of compliance well within required standards (85% and above, ICNA 2004).

Based on the outcomes of Study 1 a recommendation was made that the case study site moves to a system of measurement which has explicit reference to its education and criteria priorities, namely one which incorporates the WHO 5 Moments (Sax et al., 2009). Further, to ensure that subsequent data is fed back successfully by possessing meaning for all recipients, an adaptation of Hysong et al. (2006) Model of Actionable Feedback was proposed. This was seen as an additional tool to check that selected measurement systems are able to produce data deemed to be meaningful to all groups with API, thus allowing an *optimal effect on performance* to be targeted (Hysong et al., 2006). Without domain knowledge, from those identified as having audit process involvement, the current state of measurement may not have been noted as having such clear weaknesses, due to its apparent ability to deliver required data in a timely manner. The issues surrounding meaning, however, were uncovered as being held strongly by all groups of participants.

Access to domain knowledge also shaped Study 2, allowing a further exploration as to the impact of specific context on Fit for Purpose (FFP) of available hand

hygiene measurement technologies. Healthcare professionals were able to add their views on the FFP of selected technology examples, as well as discuss the concept of measurement using such devices as a whole. Information regarding overall limitations within the field (e.g. inability of any technologies to detect all 5 Moments) could be provided stemming from a specifically performed literature review. However the views of the healthcare professionals provided key context regarding the extent to which they perceived this to be a major barrier to measurement technologies.

Participants in Study 2 revealed interest in the concept of technology to measure hand hygiene where available (WHO Moments 1, 4, 5). However they registered concerns regarding FFP limitations, anonymity of data and resistance to innovations, and effects of over-reliance and habituation on longer term hand hygiene behaviour. Concerns were both practical and ethical, ranging from the very context specific (e.g. individual/unit level) to the wider organisational level (e.g. Patient/Staff confidentiality). None of the examples shown, in their current state, were seen by the participants as wholly suitable for an NHS setting like theirs.

Insights from the healthcare professional participants, regarding potential use of such technologies within the measurement process for hand hygiene, led to an examination of their possible suitability as an aid to education and training. The generation of meaningful data relating to hand hygiene performance at separate WHO 5 Moments (1, 4, 5) was recommended as a potential area for future attention for technology developers. The intention being to allow focused training and education to occur. Healthcare professionals felt that whilst prompts may

also be useful at these Moments, as opposed to Moments 2 and 3, such effects may be short-lived and countered by concerns regarding habituation and over-reliance. Their views regarding personal performance at Moments 2 and 3 helped shape the design of Study 3.

9.2. The Importance of Human Behaviour

Confirming the perceptions of health professionals from the case study, and existing literature, Study 3 found that hand hygiene practice can be influenced by human behaviour, namely Inherent and Elective theory. Here activities categorised as Inherent (e.g. handling soiled lined, manipulating an IV Line) were more likely to trigger hand hygiene than activities categorised as Elective (e.g. taking a Patient's blood pressure, touching a Patient's bed). A recommendation, based on a proposed link between these categories of Inherent and Elective, and the WHO 5 Moments, suggests that the latter may be conceptually split. This allows the potential for novel future avenues to be explored within the field of hand hygiene education and training. Whilst requiring further investigation to confirm the proposed conceptual split, the potential contribution to education and training would aim to reduce the current issues relating to healthcare professional apathy surrounding the topic of hand hygiene.

9.3. A Future State of Measurement

Audit processes, such as the measurement of hand hygiene seen at the case study site, require integration into a wider quality management (QM) approach to have maximum efficacy (Powell et al., 2010). The current research found that whilst a structured auditing process was in place, it lacked focus on how collected data

could be used to instigate and promote change. Therefore an additional recommendation was the adoption of a PDSA approach to allow focus to be on the use of data, as well as its generation.

To ensure that the previous recommendations regarding the importance of generating domain knowledge, the potential for technology, and the impact of human behaviour were not lost, these threads were incorporated into an overriding proposal for a future state of measurement for hand hygiene. Here, the combination of both manual and technological methods of data collection was proposed, within a PDSA framework. Such methods would allow data to be collected at each of the WHO 5 Moments, with feedback quality assessed using the adapted Hysong et al. (2006) Model of Actionable Feedback (Figure 5-15). Generated data using such a system was recommended as a foundation for education and training priorities, at unit and organisational level, to ensure relevance to healthcare professionals and maximise the potential to create a change environment (Smith and Rudd, 2010).

The future state of measurement can be investigated, firstly through establishing further the link between Inherent and Elective hand hygiene and specific WHO 5 Moments, and then through examining the impact of new measurement strategies on both healthcare professional perceptions of meaningful data and hand hygiene education. The overriding objective remains the promotion of a proven infection prevention strategy to prevent cross-contamination leading to infection. Improved measurement is a step towards achieving this goal.

9.4. Overriding Contribution to Knowledge: Meaningful Data for Behaviour Change

The thesis strongly proposes that future measurement systems, being manual, technological, or featuring a combination, must focus on the production of meaningful data to engender behaviour change.

Existing behavioural models have successfully been applied to consider intention to perform hand hygiene (e.g. Theory of Planned Behaviour; Nicol et al., 2009; Jenner et al., 2002). However they fall short of predicting actual performed behaviour, due to the effect of mediating factors such as time, available resources and human error. This thesis suggests the application and extension of behavioural Inherent and Elective theory to focus on likelihood of hand hygiene being performed.

Whilst this theory has been applied to the WHO 5 Moments to consider a before and after Patient contact split, results from this thesis suggest this has major limitations, based on an understanding of what activities are more likely to trigger hand hygiene. A more useful application is proposed here, allowing Inherent behaviour to be considered specifically at Moments 2 and 3, with Moments 1, 4 and 5specifically relating to Elective behaviour.

With Study 3 finding that hand hygiene is significantly less likely at Elective activities, and Study 2 identifying that technologies exist that may be able to monitor and prompt healthcare professional's behaviour at Moments 1, 4 and 5, practical recommendations are provided for a focus on technology development in relation to Inherent and Elective theory.

Additionally, the involvement of healthcare professionals in technology development, harnessing their domain knowledge, should ensure the generation of meaningful data, around globally recognised guidelines: the WHO 5 Moments. Crucially, meaningful data is a key element for ensuring successful long-term behaviour change in the area of hand hygiene compliance.

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Appendices

Appendix 1

Appendix 1a: What Affects Compliance, WHO (2009) Table I.16.3

Table A-1: Reproduction of part of "*Table I.16.3 Factors influencing adherence to hand hygiene practices*" (WHO, 2009, pp. 72-75) summarising existing findings relating to factors negatively influencing Hand Hygiene compliance

Factors influencing adherence to hand hygiene practices	
Factors for poor adherence / low compliance	
A. Observed risk factors for poor adherence to recommended hand hygiene practices	**References**
Doctor status (rather than a nurse)	Pittet & Perneger, 1999[737];Pittet, 2000[738]; Pittet et al., 2000[60]; Lipsett & Swoboda, 2001[730]; Hugonnet, Perneger & Pittet, 2002[334]; Rosenthal et al., 2003[651]; Zerr et al., 2005[715]; Pan et al., 2007[703]
Nursing assistant status (rather than a nurse)	Pittet & Perneger, 1999[737]; Pittet, 2000[738]; Lipsett & Swoboda, 2001[730]; Lipsett & Swoboda, 2001[730]; Hugonnet, Perneger & Pittet, 2002[334]; Rosenthal et al., 2003[651]; Arenas et al., 2005[689]; Novoa et al., 2007[700]; Pan et al., 2007[703]
Physiotherapist	Pan et al., 2007[703]
Technician	Pittet et al., 2000[60]
Male sex	Pittet, 2000[738]; Rosenthal et al., 2003[651]
Working in intensive care	Pittet & Perneger, 1999[737]; Pittet, 2000[738]; O'Boyle, Henly & Larson, 2001[729]; Hugonnet, Perneger & Pittet, 2002[334]; Rosenthal et al., 2003[651]; Pittet et al., 2004[335]
Working in surgical care unit	Lipsett & Swoboda, 2001[730]; Pittet et al., 2004[335]; Zerr et al., 2005[715]
Working in emergency care	Pittet et al., 2004[335]
Working in anaesthiology	Pittet et al., 2004(Pittet, 2004 #261}
Working during the week (vs. weekend)	Pittet & Perneger, 1999[737]; Pittet, 2000[738]

Wearing gowns/ gloves	Thompson et al., 1997[739]; Khatib et al., 1999[740]; Pittet, 2000[738]; Pessoa-Silva et al., 2007[657]
Before contact with patient environment	Zerr, 2005[715]
After contact with patient environment e.g. equipment	Zerr, 2005[715]; Pessoa-Silva et al., 2007[657]
Caring of patients aged less than 65 years old	Pittet et al., 2003[652]
Caring of patients recovering from clean/clean-contaminated surgery in postanaesthesia care unit	Pittet et al., 2003[652]
Patient care in non-isolation room	Arenas et al., 2005[689]
Duration of contact with patient (< or equal to 2 minutes)	Dedrick et al., 2007[702]
Interruption in patient-care activities	Harbarth et al., 2001[653]
Automated sink	Larson et al., 1991[217]; Pittet, 2000[738]
Activities with high risk of cross-transmission	Pittet & Perneger, 1999[737]; Pittet, 2000[738]; Pittet et al., 2000[60]; Hugonnet, Perneger & Pittet, 2002[334]; Pan et al., 2007[703]
Understaffing or overcrowding	Haley & Bregman, 1982[741]; Pittet & Perneger, 1999[737]; Harbarth et al., 1999[185]; Pittet, 2000[738]; Pittet et al., 2000[60]; O'Boyle, Henly & Larson, 2001[729]; Kuzu et al., 2005[683]
High patient-to-nurse ratio and more shifts per day (for haemodialysis unit)	Arenas et al., 2005[689]
High number of opportunities for hand hygiene per hour of patient care	Pittet & Perneger, 1999[737]; Pittet, 2000[738]; Pittet et al., 2000[60]; O'Boyle, Henly & Larson, 2001[729]; H Hugonnet, Perneger & Pittet, 2002 [334]; Pittet et al., 2003[652]; Kuzu et al., 2005[683]; Pan et al., 2007[703]; Pessoa-Silva et al., 2007[657]
B. Self-reported factors for poor adherence to hand hygiene	
Handwashing agents cause irritations and dryness	Larson & Killien, 1982[608]; Larson, 1985[742]; Pettinger & Nettleman, 1991[668]; Heenan, 1992[743]; Zimakoff et al., 1992[609]; Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Huskins et al., 1999[744]; Pittet, 2000[738]; Pittet et al., 2000[60]; Patarakul et al., 2005[745]
Sinks are inconveniently located or shortage of sinks	Larson & Killien, 1982[608]; Kaplan & McGuckin, 1986[497]; Pettinger & Nettleman, 1991[668]; Heenan, 1992[743]; Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Huskins et al., 1999[744]; Pittet, 2000[738]; Pittet et al., 2000[60]
Lack of soap, paper towel, handwashing agents	Heenan, 1992[743]; Huskins et al., 1999[744]; Pittet, 2000[738]; Pittet et al., 2000[60]; Suchitra & Lakshmi Devi, 2007[746]
Often too busy or insufficient time	Larson & Killien, 1982[608]; Pettinger & Nettleman, 1991[668]; Heenan, 1992[743]; Williams et al., 1994[747]; Larson & Kretzer, 1995[722]; Voss & Widmer, 1997[615]; Kretzer & Larson, 1998[724]; Boyce, 1999[720]; Pittet & Perneger, 1999[737]; Weeks, 1999[748]; Bischoff et al., 2000[486]; Pittet, 2000[738]; Pittet et al., 2000[60]; Dedrick et al., 2007[702]; Suchitra & Lakshmi Devi,

	2007[746]
Patient needs take priority	Kretzer & Larson, 1998[724] ; Pittet, 2000[738]; Patarakul et al., 2005[745]
Hand hygiene interferes with HCW-patient relationship	Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Pittet, 2000[738]
Low risk of acquiring infection from patients	Pittet, 2000[738]
Wearing of gloves or belief that glove use obviates the need for hand hygiene	Pittet & Perneger, 1999[737]; Pittet, 2000[738]; Pittet et al., 2000[60]
Lack of institutional guidelines/ lack of knowledge of guidelines and protocols	Larson & Killien, 1982[608]; Pettinger & Nettleman, 1991[668]; Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Boyce & Pittet, 2002[58]; Rosenthal, Guzman & Safdar, 2005[716]; Suchitra & Lakshmi Devi, 2007[746]
Lack of knowledge, experience and education	Larson & Killien, 1982[608]; Pettinger & Nettleman, 1991[668]; Suchitra & Lakshmi Devi, 2007[746]
Lack of rewards/ encouragement	Larson & Killien, 1982[608]; Pettinger & Nettleman, 1991[668]; Suchitra & Lakshmi Devi, 2007[746]
Lack of role model from colleagues or superiors	Larson & Killien, 1982[608]; Pettinger & Nettleman, 1991[668]; Muto, Sistrom & Farr, 2000[682]; Pittet, 2000[738]; Pittet et al., 2000[60]; Suchitra & Lakshmi Devi, 2007[746]
Not thinking about it, forgetfulness	Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Pittet, 2000[738]; Pittet et al., 2000[60]; Patarakul et al., 2005[745]
Scepticism about the value of hand hygiene	Pittet, 2000[738]; Pittet et al., 2000[60]; Boyce & Pittet, 2002[58]
Disagreement with recommendations	Pittet, 2000[738]
Lack of scientific information of definitive impact of improved hand hygiene on HCAI rates	Weeks, 1999[748]; Pittet, 2000[738]; Pittet et al., 2000[60]
C. Additional perceived barriers to appropriate hand hygiene	
Lack of active participation in hand hygiene promotion at individual or institutional level	Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Larson et al., 2000[713]; Pittet, 2000[738]; Pittet et al., 2000[60]; Pittet & Boyce, 2001[749]; Pittet, 2001[750]
Lack of institutional priority for hand hygiene	Pittet, 2000[738]; Pittet et al., 2000[60]; Pittet, 2001[750]
Lack of administrative sanction of non-compliers or rewarding of compliers	Kelen et al., 1991[751]; Jarvis, 1994[721]; Kretzer & Larson, 1998[724]; Boyce, Kelliher & Vallande, 2000[264]; Pittet, 2000[738]; Pittet & Boyce, 2001[749]; Pittet, 2001[750]
Lack of institutional safety climate/ culture of personal accountability of HCWs to perform hand hygiene	Larson & Kretzer, 1995[722]; Kretzer & Larson, 1998[724]; Larson et al., 2000[713]; Pittet, 2000[738]; Pittet et al., 2000[60]; Pittet & Boyce, 2001[749]; Pittet, 2001[750]; Goldmann, 2006[752]

Appendix 1b: What Improves Compliance, WHO (2009) Table I.16.3

Table A-2: Reproduction of part of "*Table I.16.3 Factors influencing adherence to hand hygiene practices*" (WHO, 2009, pp. 75-77) summarising existing findings relating to factors positively influencing Hand Hygiene compliance

Factors for good adherence/ improved compliance	**References**
Observed factors for improved compliance	
Introduction of widely accessible alcohol-based handrub (e.g. bedside handrub, small bottles/pocket-sized handrub); or combined with a multimodal multidisciplinary approach targeted at individual and institution levels.	Pittet & Perneger, 1999[737]; Bischoff et al., 2000[486]; Maury, 2000[485]; Pittet et al., 2000[60];Hugonnet, Perneger & Pittet, 2002[334]; Mody et al., 2003[754]; Brown et al., 2003[687]; Lam, Lee & Lau, 2004[648]; Pittet et al., 2004[335]; Johnson et al., 2005[494]; Zerr et al., 2005[715]; Hussein, Khakoo & Hobbs, 2007[755]; Pessoa-Silva et al., 2007[657]; Trick et al., 2007[701]; Rupp et al., 2008[707]
Multifaceted approach to improve hand hygiene (e.g. education, training, observation, feedback, easy access to hand hygiene supplies (sinks/ soap/ medicated detergents), sink automation, financial incentives, praises by superior, admonishment of suboptimal performance, administrative support, prioritization to infection control needs, active participation at institutional level)	Conly et al., 1989[663] ;Dubbert et al., 1990[666]; Larson et al., 1997[684];Rosenthal et al., 2003[651]; Won et al., 2004[756]; Rosenthal, Guzman & Safdar, 2005[716]
B. Predictive factors for hand hygiene compliance (by observational study / interventional study)	
(i) Status of HCW	
Non-doctor HCW status (with attending doctors as reference group)	Duggan et al., 2008[711]
Respiratory therapist (with nurses as reference group)	Harbarth et al., 2001[653]; Harbarth et al., 2002[686]
(ii) Type of patient care	
Under precaution care (perceived as greater risk of transmission to HCWs themselves) • care of patient under contact precautions • care of patient in isolation room	Dedrick et al., 2007[702]; Swoboda et al., 2007[699]
Completing care/ between patients	Pessoa-Silva et al., 2007[657]

(iii) Activities perceived as having a high risk of cross-contamination or cross-infection (e.g. after direct patient contact; before wound care; before/after contact with invasive devices or aseptic techniques; before/after contact with body fluid secretions; contact with nappies/diapers; or assessed by level of dirtiness of tasks) to HCWs	Lipsett & Swoboda, 2001[730];Harbarth et al., 2001[653]; Harbarth et al., 2002[686]; Kuzu et al., 2005[683]; Jenner et al., 2006[700]; Pessoa-Silva et al., 2007[657]; Trick et al., 2007[701]; Haas & Larson, 2008[709]
(iv) Type of unit • Intensive care unit • Neonatal ICU • Acute haemiodialysis unit	Novoa et al., 2007[700]; Harbarth et al., 2001[653]; Arenas et al., 2005[689]
(v) During the 3-month period after an announced accreditation visit	Duggan et al., 2008[711]
(vi) Strong administrative support	Rosenthal et al., 2003[651]
C. Determinants/ predictors/ self-reported factors for good adherence to hand hygiene (by questionnaire or focus group study)	
Normative beliefs	
Peer behaviour (role model)/perceived expectation from colleagues (peer pressure)	Wong & Tam, 2005[757]; Whitby, McLaws & Ross, 2006[725]; Sax et al., 2007[732]
Being perceived as role model (for doctors)/with good adherence by colleagues	Pittet et al., 2004[335]
Perceived positive opinion / pressure from superior or important referent others e.g. senior doctors, administrators	Seto et al., 1991[758]; Pittet et al., 2004[335]; Pessoa-Silva et al., 2005[731]; Whitby, McLaws & Ross, 2006[725]; Sax et al., 2007[732]
Control beliefs	
Perception that hand hygiene is easy to perform/ easy access to alcohol-based handrub	Pittet et al., 2004[335]; Sax et al., 2007[732]
Perceived control over hand hygiene behaviour	Pessoa-Silva et al., 2005[731]
Attitudes	
Awareness of being observed	Pittet et al., 2004[335]

Positive attitude towards hand hygiene after patient contact	Pittet et al., 2004[335]
Perceived risk of infection (level of dirtiness) during patient contact/ perceived high public health threat	Parker et al., 2006[254]; Whitby, McLaws & Ross, 2006[725]
Beliefs in benefits of performing hand hygiene/ protection of HCWs from infection	Shimokura et al., 2006[759]; Whitby, McLaws & Ross, 2006[725]
Translation of community hand washing behaviour (behaviour developed in early childhood) into healthcare settings (for nurses in handwashing)	Whitby, McLaws & Ross, 2006[725]
Others	
Female sex	Sax et al., 2007[732]
HCW status – technician	Shimokura et al., 2006[759]
Previous training	Sax et al., 2007[732]
Participation in previous hand hygiene campaign	Sax et al., 2007[732]
Patient expectation (for doctors)	Sax et al., 2007[732]
D. Factors for preferential recourse to handrubbing vs handwashing	
Doctors e.g. critical care (with nurses as reference group)	Pittet et al., 2000[60]; Hugonnet, Perneger & Pittet, 2002[334]; Dedrick et al., 2007[702]; Trick et al., 2007[701]
Activities with high risk of cross-transmission/ level of dirtiness	Hugonnet, Perneger & Pittet, 2002[334]; Kuzu et al., 2005[683]
High activity index (>60 opportunities per hour)	Hugonnet, Perneger & Pittet, 2002[334]

Appendix 1c: ICNA. (2004). Audit tools for monitoring infection control standards 2004

Manual tool used for current audit process at case study site. Of particular relevance is the Hand Hygiene tool, pp. 32-34, reproduced here:

INFECTION CONTROL AUDIT TOOLS

Hand hygiene

Standard: Hands will be decontaminated correctly and in a timely manner using a cleansing agent, at the facilities available to reduce the risk of cross infection

Date ..... **Ward**..... **Auditor**.....

		Yes	No	N/A	Comments
1	Liquid soap is available at all hand washing sinks				
2	Liquid soap must be single use cartridge dispensers				
3	Dispenser nozzles are visibly clean				
4	Soft absorbent paper towels are available at all hand washing sinks				
5	Wall mounted or pump dispenser hand cream is available for use				
6	Antibacterial solutions/scrubs are not used for social hand washing				
7	Antibacterial solutions are used for invasive procedures and surgical scrubs				
8	There are no nail brushes on hand wash sinks in clinical areas				
9	The hand wash sinks are free from used equipment and inappropriate items				
10	Hand wash sinks are dedicated for that purpose				
11	Hand wash sinks conform to HBN 95. Check that they do not have plugs, overflows or that the water jet does not flow directly into the plughole				
12	There are sufficient numbers of hand wash sinks available in accordance with national and local guidance (e.g. one sink per four beds in acute care settings)				
13	Access to hand wash sinks is clear				
14	Hand washing facilities are clean and intact. (Check sinks, taps, splash backs)				
15	There is appropriate temperature control to provide suitable hand wash water at all sinks				
16	Elbow operated or automated taps are available in hand wash sinks in clinical areas				

4.0 Audit tools 4.9 Hand hygiene 2 of 3

	Alcohol hand rub is available for use throughout clinical areas, check:	Yes	No	N/A	Comments
17a	Entrance/exits to wards and departments				
17b	Directly accessible at the point of care (e.g. one dispenser per bed/per four beds as per local and national standards)				
17c	Portable for clinical procedures				
18	No wrist watches/stoned rings or other wrist jewellery are worn by staff carrying out patient care				
19	Staff nails are short, clean and free from nail varnish				
20	Posters promoting hand decontamination are available and displayed in areas visible to staff before and after patient contact				
21	Staff have received training in hand hygiene procedures within the last year. (Ask a member of medical, nursing, ancillary and AHP staff)				
22	Patients' are offered hand hygiene facilities after using the toilet/commode/bedpan e.g. hand wipe				
23	Patients' are offered hand hygiene facilities prior to meals				
	Observational audit				
24	Nursing staff use the correct procedure for decontaminating hands (observe practice)				
25	Medical staff use the correct procedure for decontaminating hands (observe practice)				
26	Allied Health Care Professionals use the correct procedure for decontam-inating hands (observe practice)				
27	Ancillary staff use the correct procedure for decontaminating hands (observe practice)				
28	Nursing staff can indicate when it is appropriate to use alcohol rub				
29	Medical staff can indicate when it is appropriate to use alcohol rub				
30	Allied Health Care Professionals can indicate when it is appropriate to use alcohol rub				
31	Ancillary Staff can indicate when it is appropriate to use alcohol rub				

4.0 Audit tools 4.9 Hand hygiene 3 of 3

	Hand hygiene is performed in the following circumstances: (observe practices)	Yes	No	N/A	Comments
32a	Following patient contact				
32b	After removal of gloves				
32c	Prior to clinical procedures				
32d	After a clinical procedure				
32e	Prior to handling food				
32f	After handling contaminated items				
32g	After leaving an isolation room				

Appendix 2

Appendix 2a: Types of Hand Hygiene Technology

Identified through the structured literature review (Chapter 3) and used to facilitate the discussions held during the semi-structured interviews featured in Study 2 (Chapter 6). These examples (Figures A-1 – A-3) were shown either using a laptop presentation or using paper displays.

Figure A-1: Healthcare Professional "Badge" system, as presented visually to participants in Study 2:

The process of the badge, with its ability to monitor entrance to a specific area, prompt hand hygiene behaviour through the use of visual cues, and detect and report successful hand hygiene through the use of vapour sensors, was discussed using information available on the commercial website

Figure A-2: Healthcare Professional "Dispenser" system, as visually presented to participants in Study 2.

The dispenser system, including the manual uploading of data into a pre-prepared data entry form to allow report generation, was discussed based on information available on the commercial website

Figure A-3: Healthcare Professional "Surveillance" system, as shown to participants in Study 2

The comprehensive wireless system, comprising of wearable monitors and dispensers, alongside wall-mounted dispensers, interacting with sensors, was discussed based on information available on the institute website and presented in academic papers

Appendix 2b: Types of Hand Hygiene Technology: Details

Table A-3: 19 Technologies identified through the Fit For Purpose (FFP) structured literature review (Chapter 3)

Paper identified through FFP Literature Review	Brief Description of Technology
Armellino et al. (2012)	Video technology using remote auditors. Sensors on doors time stamp healthcare professional entry/exit, 20 second video clip either side of time stamp reviewed to check for hand hygiene event. Feedback sent to 'live' LED board in hospital corridors, and email feedback sent to e.g. Nurse Managers.
Boscart et al. (2009)	Patient Zone focused technology using infrared detection and badges. Discusses future work which may help identify when hand hygiene is required in more complicated settings than entry/exit i.e. IV Line manipulation - based on body positioning, healthcare professional behaviours
Cheng et al. (2011)	Healthcare professional badges designed to detect hand hygiene at WHO Moments 1 and 4 via interaction with beacons situated within Patient Zones. Data stored via wireless transmission.
Do (2009)	Review article of Smart Room to enable hand hygiene - including use of lights, positioned monitors and RFID for monitoring and feedback.
Edmond et al. (2010)	Healthcare professional badges detect alcohol in gel/soap, LED turning from red to green if hand hygiene occurs after room entry/exit (visual prompt/feedback). Door sensors and badges link to wireless system to record hand hygiene.
Polgreen et al. (2010)	Developmental technology using MOTES, thus not requiring RFID. Based on entry/exit. Healthcare professional badges, with high levels of specificity and sensitivity. Can cope with many badges in one area, data stored via wireless transmission.
Sahud et al. (2012)	Healthcare professional badge, providing feedback, interacting with triggers able to detect room entry/exit and hand hygiene via radio frequency.

Anon (2012)	Monitors hand hygiene through use of tap, quality judged through time used (e.g. length of wash). No individual data recorded.
Anon (2011)	Healthcare professional badge system using RFID allowing data recording and real-time (LED/vibration) prompting upon approaching Patient Zone.
Cantrell (2012)	Compares measured dispenser usage to benchmarked hand hygiene rates (using algorithm from study of hand hygiene observations based on 5 Moments in US setting).
Czyzewski (2011)	Uses thermal detection, senses activity within defined zones and compares with expected activity; already being trialled within NHS settings.
Ferenc (2012)	Healthcare professional badge system with real-time prompting (LED/audio), related to Patient Zone. Has a data recording capability, with use of both wireless and RFID technology.
Hlady et al. (2010)	Electronic auditing tool, designed to allow greater accuracy and efficiency than traditional manual auditing.
Jeppsson (2011)	Healthcare professional badge using RFID interacts with dispensers to deliver individually tailored feedback. Can detect hand hygiene opportunities via proximity to sensors located in dispensers.
Lorenzi (2011)	Potential for dispenser based system, using real-time locating systems (RTLS) to records usage at specific units, e.g. entry/exit.
Sealed Air	Currently food industry specific - detects use of PPE (e.g. gloves) and uses 'Smart Video' technology to store images/film of when individuals are not wearing correct PPE when expected. Algorithms define expectations of correct procedures.
Centrak	Healthcare professional badge linked to dispenser usage on entry/exit to specified zones, using both infrared and wireless technology. Real-time prompting and RTLS additions possible.
Surewash	Using video technology, hand hygiene at sink is audited, providing real-time time feedback and stored data on frequency and quality of hand hygiene technique.
Hygenix	Bracelet worn by healthcare professionals wirelessly interacts with tap/soap dispensers, recording hand hygiene events and duration. Device also provides real-time prompt at room entry/exit.

Appendix 3

Appendix 3a: Participant Information Document

Participants were provided an information document to enable them to provide informed consent. These were identical regardless of role, except for item 2: "Why have I been invited?", which was worded one of two ways:

1. You are part of the **Infection Control Team**, and thus it is felt that you will have direct insight and knowledge of the current Hand Hygiene Audit process at UHCW.

OR

2. Healthcare workers involved in this research will be represented by 3 levels:

   Doctors/Junior Doctors, Nurses and Healthcare Assistants from a NHS acute setting.

   You have been invited as it is felt that you are able to represent one of these levels well.

The details of the Direct Participant role were slightly different depending on role:

[*IPCT*] Direct Participants will be asked to participate in an Observatory phase of research, allowing the Lead Researcher to follow their usual Audit process.

Direct Participants may be invited to attend *up to 2** (1-hour) Focus Groups on Hand Hygiene.

(**The number of Focus Groups you will attend will be determined by your availability. Further information regarding Focus Groups will be outlined in the Participation Pack).*

Direct Participants may be asked (and can request) to participate in a 30 minute – 1 hour 1-2-1 Interview.

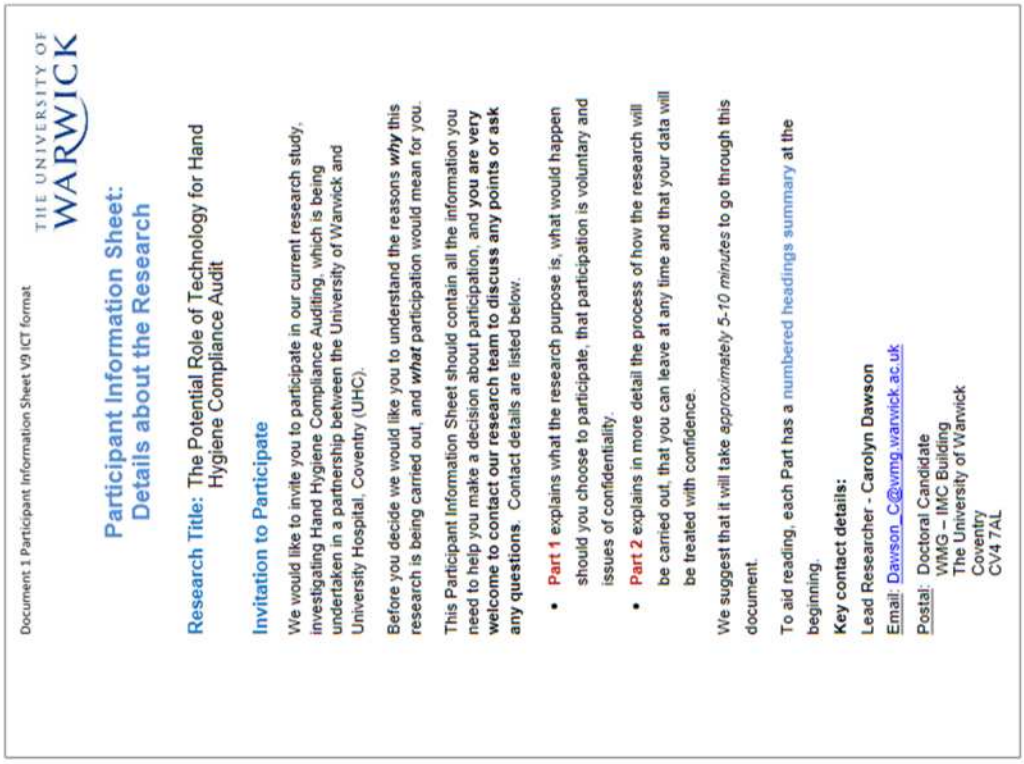
Access to a Research Group Website will also be available (see In-Direct Participants, next page).

Focus Groups will be recorded using audio and visual means (e.g. Dictaphone, Video Camera). This is to help with data analysis, and only the research team will have access to the material.

[*RoF/SoO*] Direct Participants may be asked (and can request) to participate in a 30 minute – 1 hour 1-2-1 interview.
Access to a Research Group Website will also be available (see In-Direct Participants, next page).

Interviews will be recorded using audio means (e.g. Dictaphone). This is to help with data analysis, and only the research team will have access to the material.

The example provided here was given to the GoD participants in the research.
Of note, all participants were notified of the decision to change Focus Groups to interviews (Group or individual). This was discussed prior to consent being taken.



Document 1 Participant Information Sheet V9 ICT format

THE UNIVERSITY OF WARWICK

Participant Information Sheet: Details about the Research

Research Title: The Potential Role of Technology for Hand Hygiene Compliance Audit

Invitation to Participate

We would like to invite you to participate in our current research study, investigating Hand Hygiene Compliance Auditing, which is being undertaken in a partnership between the University of Warwick and University Hospital, Coventry (UHC).

Before you decide we would like you to understand the reasons ***why*** this research is being carried out, and ***what*** participation would mean for you.

This Participant Information Sheet should contain all the information you need to help you make a decision about participation, and **you are very welcome to contact our research team to discuss any points or ask any questions**. Contact details are listed below.

- **Part 1** explains what the research purpose is, what would happen should you choose to participate, that participation is voluntary and issues of confidentiality.
- **Part 2** explains in more detail the process of how the research will be carried out, that you can leave at any time and that your data will be treated with confidence.

We suggest that it will take *approximately 5-10 minutes* to go through this document.

To aid reading, each Part has a numbered headings summary at the beginning.

Key contact details:

Lead Researcher - Carolyn Dawson

Email: Dawson_C@wmg.warwick.ac.uk

Postal: Doctoral Candidate
WMG – IMC Building
The University of Warwick
Coventry
CV4 7AL

5th October 2011

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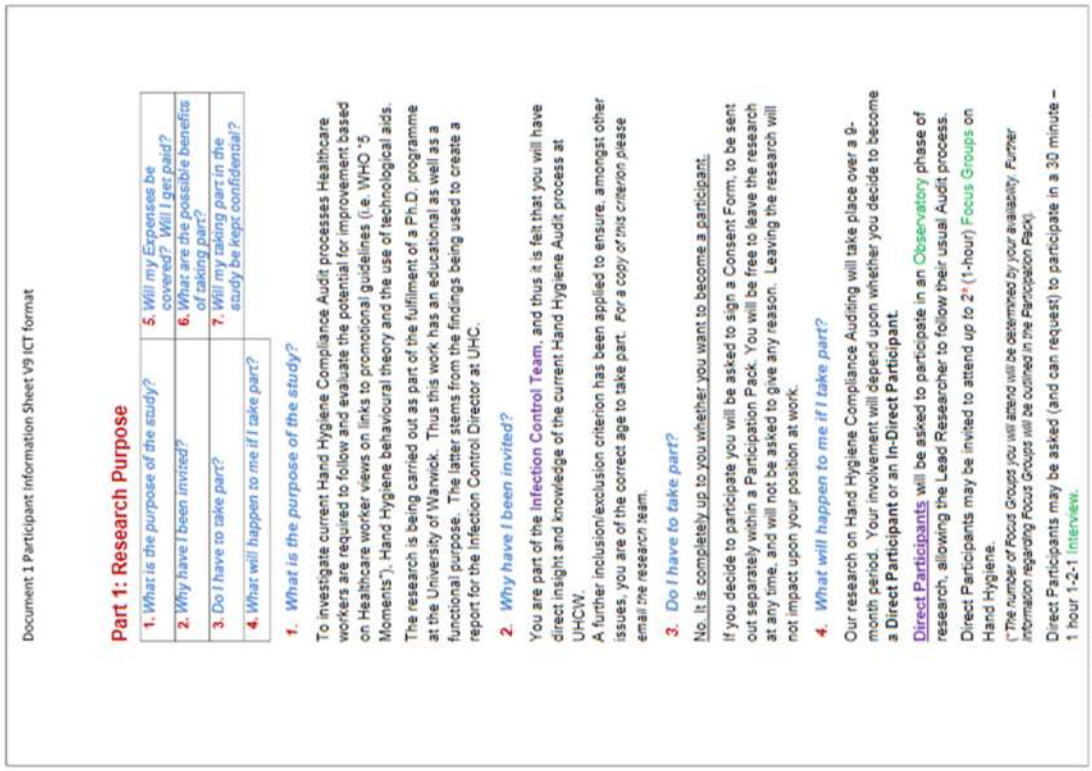

Document 1 Participant Information Sheet V9 ICT format

Part 1: Research Purpose

1. *What is the purpose of the study?*	5. *Will my Expenses be covered? Will I get paid?*
2. *Why have I been invited?*	6. *What are the possible benefits of taking part?*
3. *Do I have to take part?*	7. *Will my taking part in the study be kept confidential?*
4. *What will happen to me if I take part?*	

1. *What is the purpose of the study?*

To investigate current Hand Hygiene Compliance Audit processes Healthcare workers are required to follow and evaluate the potential for improvement based on Healthcare worker views on links to promotional guidelines (i.e. WHO '5 Moments'). Hand Hygiene behavioural theory and the use of technological aids. The research is being carried out as part of the fulfilment of a Ph.D. programme at the University of Warwick. Thus this work has an educational as well as a functional purpose. The latter stems from the findings being used to create a report for the Infection Control Director at UHC.

2. *Why have I been invited?*

You are part of the Infection Control Team, and thus it is felt that you will have direct insight and knowledge of the current Hand Hygiene Audit process at UHCW.
A further inclusion/exclusion criterion has been applied to ensure, amongst other issues, you are of the correct age to take part. *For a copy of this criterion please email the research team.*

3. *Do I have to take part?*

No. It is completely up to you whether you want to become a participant.

If you decide to participate you will be asked to sign a Consent Form, to be sent out separately within a Participation Pack. You will be free to leave the research at any time, and will not be asked to give any reason. Leaving the research will not impact upon your position at work.

4. *What will happen to me if I take part?*

Our research on Hand Hygiene Compliance Auditing will take place over a 9-month period. Your involvement will depend upon whether you decide to become a **Direct Participant** or an **In-Direct Participant**.

Direct Participants will be asked to participate in an Observatory phase of research, allowing the Lead Researcher to follow their usual Audit process.
Direct Participants may be invited to attend *up to* 2* (1-hour) Focus Groups on Hand Hygiene.
(*The number of Focus Groups you will attend will be determined by your availability. Further information regarding Focus Groups will be outlined in the Participation Pack).
Direct Participants may be asked (and can request) to participate in a 30 minute – 1 hour 1-2-1 interview.

5th October 2011

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Part 2: Further Details

8. What will happen if I don't want to carry on with the study?	12. What will happen to the results of the research study?
9. Loss of capability to consent	13. Who is organising and funding the research?
10. What if there is a problem?	14. Who has reviewed the study?
11. Will my taking part in this study be kept confidential?	15. Further information and contact details

8. What will happen if I don't want to carry on with the study?

Should you wish to withdraw from the research study, even after you have contributed information (e.g. attended a Focus Group) you are fully entitled to do so. You will need to contact the research team to notify them of your decision, but you will not have to give a reason.
All personal data will be destroyed when the research is completed, however you can request that this occurs upon the point you decide to leave the study.

Due to the design of the research (e.g. Use of Focus Groups, Shared Website Forums) it may be impossible to remove *all* data you have contributed up to the point you decide to leave.

9. Loss of capability to consent

If you agree to participate in this research you will be asked for your Informed Consent, and asked to agree to 7 points. One of these relates to the use of your contributed data in the highly unlikely eventuality that you later *lose the ability to give consent* during the research period.
This change in status would mean that you would no longer be expected to participate (i.e. we would withdraw you and destroy your personal data immediately). However, as outlined above it may be impossible to remove data once it is contributed.

10. What if there is a problem?

Should you wish to speak to someone outside of the direct research team then the Research and Development Services Manager UHC can be contacted:

Ms Ceri Jones
Research & Development Department
First Floor Rotunda (opposite Cardiac)
University Hospital
Clifford Bridge Road
Coventry
CV2 2DX

Telephone: 02476 966196 (ext. 26196) Email: ceri.jones@uhcw.nhs.uk

Access to a Research Group Website will also be available (see In-Direct Participants, next page).

Focus Groups will be recorded using audio and visual means (e.g. Dictaphone, Video Camera). This is to help with data analysis, and only the research team will have access to the material.

In-Direct and Direct Participants will have access to a Research Group Website to allow contribution to online feedback forums and to keep up-to-date with the research. The amount of time spent on this activity is at participant's discretion. For In-Direct Participants this will be the only research involvement.

5. Will my Expenses be covered? Will I get paid?

No. It has been arranged that activities requiring Direct Participants to be away from the clinical area (e.g. Focus Groups) should take place during regular shift hours. Therefore additional expenses should not be incurred. In some cases there is potential for participation to count towards your individual PDP (Personal Development Plan). Your line manager may be able to advise you of this.

6. What are the possible benefits of taking part?

Research has shown that Healthcare workers have strong and well thought out opinions on the way medical guidelines are both created and carried out.

By participating in this research you will have the opportunity to express your views of a critical, yet mandatory aspect of healthcare life on NHS wards – Hand Hygiene Compliance Auditing - including the chance to offer insight as to why a Global set of guidelines ("My 5 Moments for Hand Hygiene") may be difficult to monitor, and what issues you may have experienced in trying to obtain or measure the required Hand Hygiene standards.

This research is being funded by a leading innovative centre (WIMRC – Warwick Innovative Manufacturing Research Centre) and has the support from a highly skilled and multi-disciplined team of advisors, from the fields of Social Science, Infection Control, Engineering, Psychology and Medicine.

7. Will my taking part in the study be kept confidential?

Ethical and legal requirements regarding your personal data, and data generated during this research project will be met. Personal data will be kept confidential, and contributed data will be anonymised. *Further details on this are covered in Part 2 of the Participant Information Sheet.*

This completes Part 1 of the Participant Information Sheet.

If the information covered in Part 1 has interested you, and you feel you may wish to become involved, ***please continue on to Part 2***. This will provide additional information to help you with your decision.

with the researcher – you will be able to use this facility to provide information you perhaps want to keep confidential from other members of the group.

Data collected from *Interviews* will be in 2 formats, auditory and written.

A Dictaphone will be used to aid data analysis; the written information will be researcher notes.

Under no circumstances will information be made public in an identifiable format i.e. any data you contribute will be anonymised by the use of pseudonyms. *For further details please email the research team.*

Data Storage and Destruction

Your data will be stored securely for up to 10 years after which the data will be effectively destroyed.

Further Research

Should further research in this area go ahead your data may be of benefit. In such a case you would be contacted separately and asked for consent. Your data will not be used for any other purpose than that outlined here unless you are asked for, and give, express permission.

12. What will happen to the results of the research study?

Primarily the results of this research study will form the basis of a dissertation for a Ph.D. qualification from the University of Warwick.

A report is also to be presented to the Infection Control Director of University Hospitals Coventry and Warwickshire NHS Trust, who will also be instrumental in defining the exact requirements for its scope.
Participants involved in this research will be able to keep up-to-date with the research and the findings via the Research Group Website.

13. Who is organising and funding the research?

The Lead Researcher responsible for the study - Carolyn Dawson – is a WIMRC Doctoral Candidate, supervised by Professor Jeremy Wyatt of the Institute of Digital Health, WMG, University of Warwick.
The research is funded by WIMRC – Warwick Innovative Manufacturing Research Centre based at the University of Warwick.

14. Who has reviewed the study?

To protect your interests as a participant the research proposal has been reviewed, and received a favourable opinion by the National Research Ethics Service and the UHCW R&D Department

You can contact an independent representative (Deputy Registrar) at the University of Warwick:

Ms Nicola Owen
Deputy Registrar's Office
University of Warwick
Coventry
CV4 8UW

Telephone: 024 7652 3704 (ext. 22713) Email: nicola.owen@warwick.ac.uk

11. Will my taking part in this study be kept confidential?

All research involving NHS settings has to be passed by the National Research Ethics Service - a division of the NHS National Patient Safety Agency, and the specific Trust R&D Department.

You may wish to consider whether these issues will cause concern before deciding to participate.

If you become a Direct Participant you will be asked to take part in activities during working hours, thus participation will not be confidential i.e. your peers will know you are taking part. It is likely that you will know some/all of the other Healthcare Worker members of the Focus Group.

If you become an *In-Direct Participant* you will be able to take part in on-line activities during your own time. Participation can be confidential, i.e. only you and the research team will know of your involvement unless you chose to share the information.

For all participants the data you contribute and your personal data will be kept confidential (see below).

Personal Data

This will be stored either on a University computer or in a locked filing cabinet housed within a secure research room on the University of Warwick campus. You would be able to request copies of your data to check for accuracy. This research is being completed as part of a Ph.D. programme, supervised by 2 senior research academics, who may access your data to ensure academic procedures are being correctly followed.

Research Data

Data collected from the *Observatory* phase will be written only.

Data collected from the *Focus Groups* will be in 3 formats, visual, auditory and written.

A video camera and Dictaphone will be used to aid data analysis. Written information will come from participants, invited to make notes/share information

15. *Further information and contact details*

This section gives other sources of information you may find of use in making your final decision on participation, and of interest should you decide to help us.

- World Health Organisation: "My 5 Moments for Hand Hygiene": www.who.int/gpsc/tools/Five_moments/en/index.html
- National Patient Safety Agency: "Cleanyourhands Campaign": www.npsa.nhs.uk/cleanyourhands
- Reducing Hospital Acquired Infections in Hospitals in England: www.nao.org.uk/publications/0809/reducing_healthcare_associated.aspx

You may also wish to contact your line manger/HR representative with regard to whether your participation will count towards your PDP.

Lead Researcher - Carolyn Dawson

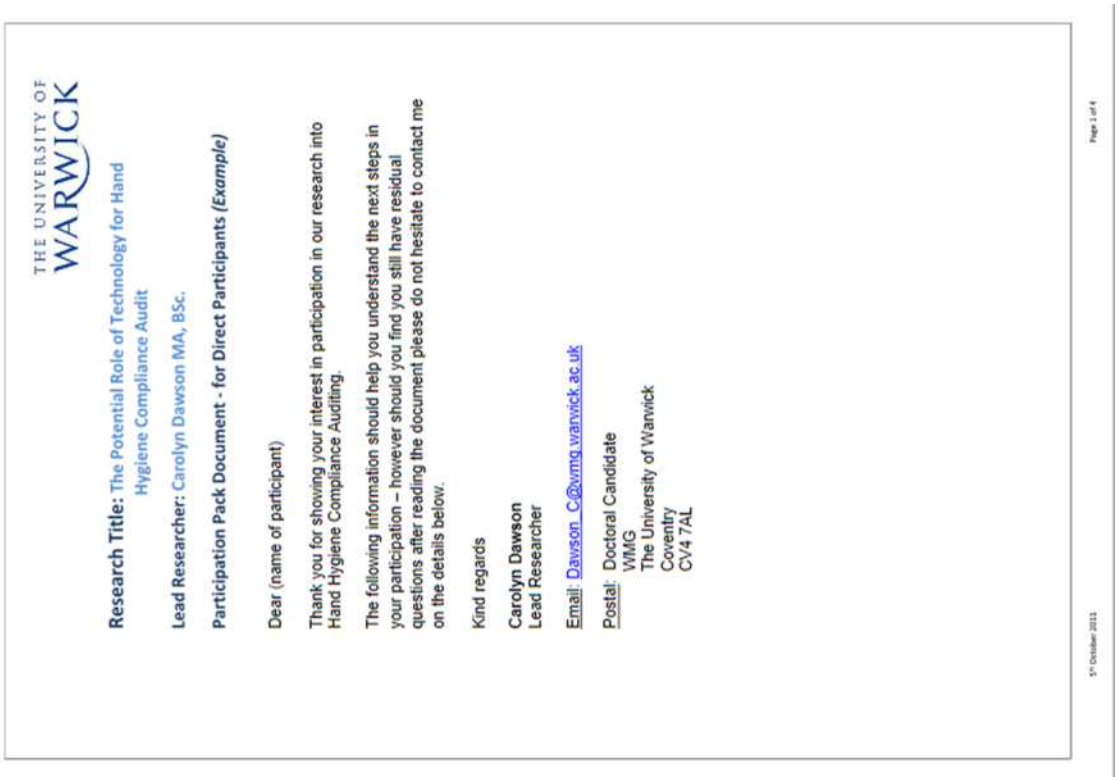
Email: Dawson_C@wmg.warwick.ac.uk

Postal: Doctoral Candidate
WMG – IMC Building
The University of Warwick
Coventry
CV4 7AL

Appendix 3b: Participation Pack

Participants who responded positively to the Participant Information Document were provided with subsequent information via tailored Participation Packs, depending on the specific activities they were willing to take part in (e.g. Interview, Observation).

An example of this pack, for an IPCT member potentially taking part in Participatory Observations, an Interview and having access to the Research Website (planned, but later discarded) is included here.



THE UNIVERSITY OF WARWICK

Research Title: The Potential Role of Technology for Hand Hygiene Compliance Audit

Lead Researcher: Carolyn Dawson MA, BSc.

Participation Pack Document - for Direct Participants *(Example)*

Dear (name of participant)

Thank you for showing your interest in participation in our research into Hand Hygiene Compliance Auditing.

The following information should help you understand the next steps in your participation – however should you find you still have residual questions after reading the document please do not hesitate to contact me on the details below.

Kind regards

Carolyn Dawson
Lead Researcher

Email: Dawson_C@wmg.warwick.ac.uk

Postal: Doctoral Candidate
WMG
The University of Warwick
Coventry
CV4 7AL

THE UNIVERSITY OF WARWICK

Observatory Phase

An observation (shadowing) of your role in the Hand Hygiene Audit process at UHCW by the Lead Researcher will take place within the next few months. A convenient specific time/date will be arranged directly with you.

Interview

An interview with the Lead Researcher, on the topic of your role and experience of the current Hand Hygiene Audit process at UHCW, will take place within the next few months. A convenient specific time/date will be arranged directly with you.

Recording Data

The Interview will be recorded using only audio technology. The records will be kept strictly confidential, with the actual hard copies (e.g. tapes, USB hard drives) being stored in locked cabinets and transcribed information will be anonymised – thus no research data will be identifiable back to you as an individual.

Only the Lead Researcher and 2 other academics (making up the academic supervisory team) will have access to the Research data. The academic supervisory team will have access to the data to ensure that research methodology is being correctly applied – at all times strict codes of confidentiality will be adhered to with reference to your data.

Personal Data

Your personal data record will remain open to you at all times during the research period, and as such should you wish to request a copy of the information held regarding you (i.e. your name and contact details) to check for accuracy please contact the Lead Researcher.

Research Data

As outlined in the Participant Information Sheet, due to the nature of the research – the use a Shared Website – it may be impossible to remove all of your contributed data should you decide to leave the research at any point.

You will, however, be able to request that any 1-2-1 interview you may take part in be removed up to the point that data analysis begins. You will be further informed regarding the date limits regarding this option should you participate in a 1-2-1 interview.

THE UNIVERSITY OF WARWICK

What is the Participation Pack?

This Participation Pack contains 4 items to help you prepare as a participant in our research.

Contents: 1 x Participation Pack Document
1 x Participant Information Sheet
2 x Consent Forms
plus 1 x Stamped Address Envelope for returning the Consent Form

Please contact the Lead Researcher (details Page 1) if any of these items are missing.

The Participation Pack Document outlines in more detail key points which were touched upon in the Patient Information Sheet you were originally sent, and includes information regarding our Research Website and Consent and Confidentiality.

This document is tailored to give information only on the Research aspects you will be taking part in.

A copy of the Participant Information Sheet is included for your reference.

A Consent Form is included for you to read, check, sign and return – a stamped addressed envelope is provided for this purpose. Alternatively you can hand this form to the Lead Researcher prior to the Observation.

THE UNIVERSITY OF WARWICK

Research Group Website

A Research Group Website has been created specifically for our Research Group to discuss and share information relating to Hand Hygiene Compliance Auditing.

You can find it at: http://www.networks.nhs.uk/nhs-networks/hand-hygiene-and-technology-wmg-uhcw

The website is password-protected, so only those involved in this research will have access to it. Your password and username will be sent to you once the Lead Researcher has received your signed Consent form (see below).

At this website you will be able to add comments to specific forum threads and keep up-to-date with our research progress. You will also be able to contact the Lead Researcher directly with specific queries or comments relating to themes and issues raised during the research.

When using the website you can remain anonymous through the use of a pseudonym issued by the Lead Researcher. This will be added to your Personal Data file, and thus the data you contribute will be linked to your profile. This will, of course, be treated with the same level of confidence as all the other research data.

Consent Form

Within this pack you will find two copies of a Consent form, referred to in the Participant Information Sheet. Please read this form through carefully, and once you are clear you agree with each of the points, please initial each section and sign where requested on both copies.

If you have any problems with this form please contact the Lead Researcher.

Please send both copies of this Consent Form back in the pre-paid envelope or bring them with you to the Observation.

A copy signed by the Lead Researcher will be returned to you for your records.

Appendix 3c: Participant Consent Form

All participants were asked to complete the following consent form prior to their involvement in the research.

CONSENT FORM

Participant Identification Number:_____
Direct or In-Direct Participant:_____
Title of Project: _____
Name of Researcher: _____

Please **Initial** box

1. ***I confirm*** that I have read and understand the information sheet dated..... (version.....) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. ***I understand*** that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my working circumstances, organisation membership or legal rights being affected. ☐
3. ***I agree*** to the use of visual/audio recording materials during Focus Groups/Interviews as necessary. **(In-Direct Participants please leave box empty)** ☐
4. ***I agree*** to the use of anonymised direct quotes for the purpose of disseminating the findings of this research. ☐
5. In the unlikely event that I lose the capability to consent during the research period ***I agree*** that data I have already contributed may still be used. ☐
6. ***I understand*** that relevant sections of data collected during the study may be looked at by responsible individuals from the University of Warwick or from regulatory authorities where it is relevant to their taking part in this research. ☐
7. ***I agree*** to take part in the above study. ***I understand*** that it is being undertaken in part fulfilment of an academic Ph.D. qualification and therefore will be being supervised by 2 other research academics, and the data stored for up to 10 years. ☐

Name of Participant _____ Date_____

Signature_____

Name of Person taking Consent _____ Date_____

Signature_____

When completed: 1 for participant; 1 for researcher site file

Appendix 3d: Interview Schedules

Interviews were guided by six different schedules depending on the role of the interviewee, as discussed in the Study methods. Here all six schedules are presented to allow both major and minor differences to be seen.

Interview Schedule Copy March 2013

➢ Preliminary Interview Objectives

3 separate categories –

1. Generators of Data (IPCT)
2. Recipients of Feedback (Modern Matrons/Ward Managers)
3. Subjects of Observation (Ward-Based Healthcare Professionals)

Interview Schedule 1: Infection Control Matron

Audit Process Sub-Group: Background to the Audit Process

Related Studies: 1, 2

Interview Schedule	Probe No.	Key themes to cover	Study/Aim
		STUDY 1	
1	1	Describe the Audit process. How does IC Matron see the actual process? (*Burden? Data Accuracy? How are Audit times chosen – busy/quiet – representative?*)	S1/A1: Identify Tools Used S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting S1/A3: Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
1	2	What output IC Matron currently receives from Hand Hygiene measurement/monitoring – current level of dis/satisfaction	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
1	3	What IC Matron sees as current limitations/problems/areas for development (*already mentioned data accuracy/validity/time spent*)	S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
1	4	Does IC Matron have views on the current Audit Tool as a mechanism for Monitoring/Measuring (and Feedback) Hand Hygiene compliance	S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help?
		STUDY 2	
1	5	With regard to the current ICNA "Observed" Audit section (e.g. questions 32a-g) are any of these particularly difficult to comply with. For performing Audit? For performing Hand Hygiene? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with

Interview Schedule 2: Infection Control Team Data Analyst

Audit Process Sub-Group: Background to the Audit Process

Related Studies: 1, 2

Interview Schedule	Probe No.	Key themes to cover	Study/Aim
		STUDY 1	
2	1	What data, relating to Hand Hygiene Audits, is currently produced?	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
2	2	How is this data produced, handled, analysed and by whom?	S1/A1: Identify Tools Used S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
2	3	Are there any current validity/accuracy concerns – internal/external? (*#N/A query*)	S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
2	4	Is the data used effectively (*opinion*) – how could it be used differently?	S1/A3: Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved
2	5	Description of an "Ideal Scenario" – (for example) frequency and type of data collected to reflect Hand Hygiene compliance (at the 5 Moments) in order to be valid/accurate (*especially if concerns raised*)	n/a

Interview Schedule Copy March 2013

1	6	With regard to the WHO 5 "Moments" are any of these particularly difficult to comply with? For performing Audit - potentially? For performing Hand Hygiene? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with
1	7	Description of an "Ideal Scenario" – what information is needed about Hand Hygiene compliance (at the "5 Moments") in order to improve it?	n/a
1	8	Current knowledge of Hand Hygiene Monitoring/Measuring/Feedback) technologies available – personal view (*give examples to aid discussion*)	n/a
1	9	View of technology for "5 Moments" compliance – any (strong) views on individual moments that should/should not be considered?	S2/A4: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of hand hygiene compliance in their setting? S2/A5: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?

4	5	With regard to the WHO 5 "Moments" are any of these particularly difficult to comply with? For performing Audit - potentially? For performing Hand Hygiene? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with
4	6	Description of an "Ideal Scenario" – how could the Measurement/Monitoring (and feedback) of Hand Hygiene Compliance be achieved in order to improve adherence (to the 5 Moments)?	n/a
4	7	Current knowledge of Hand Hygiene (Monitoring/Measuring/Feedback) technologies available – personal view (*give examples to aid discussion*)	n/a
4	8	View of technology for "5 Moments" compliance – any (strong) views on individual moments that should/should not be considered?	S2/A4: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of hand hygiene compliance in their setting? S2/A5: Reactions to technology – do cu healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?
4	9	View of anonymity in technology	n/a
4	10	Revisit "Ideal Scenario" (*if technology was not previously mentioned, Anonymity if not previously mentioned*)	n/a

Interview Schedule 3: Infection Control Team 1 (Training)

Audit Process Sub-Group: Generators of Data (IPCT)

Related Studies: 1, 2

Interview Schedule	Probe No.	Key themes to cover	Study/Aim
		STUDY 1	
3	1	Discuss how are HP trained in Hand Hygiene compliance (*leading to "5 Moments"*)	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting S1/A3: Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved
3	2	Describe the Audit process. How does ICT1 see the actual process? (*Burden? Data Accuracy?*)	S1/A1: Identify Tools Used S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
3	3	Does ICT1 have views on the current Audit Tool as a mechanism for Monitoring/Measuring (and Feedback) Hand Hygiene compliance (*unrelated to Training?*)	S1/A3: Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help?
		STUDY 2	
3	4	With regard to the current ICNA "Observed" Audit section (e.g. questions 32a-g)? are any of these particularly difficult to comply with? For performing Audit? For performing Hand Hygiene? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with

4	5	With regard to the WHO 5 "Moments" are any of these particularly difficult to comply with? For performing Audit - potentially? For performing Hand Hygiene? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with
4	6	Description of an "Ideal Scenario" – how could the Measurement/Monitoring (and feedback) of Hand Hygiene Compliance be achieved in order to improve adherence (to the 5 Moments)?	n/a
4	7	Current knowledge of Hand Hygiene (Monitoring/Measuring/Feedback) technologies available – personal view (*give examples to aid discussion*)	n/a
4	8	View of technology for "5 Moments" compliance – any (strong) views on individual moments that should/should not be considered?	S2/A4: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/mon back of hand hygiene compliance ting? S2/A5: Reactions to – do current healthcare professi xisting innovations as usef measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?
4	9	View of anonymity in technology	n/a
4	10	Revisit "Ideal Scenario" (*if technology was not previously mentioned, Anonymity if not previously mentioned*)	n/a

Interview Schedule 4: Infection Control Team 2

Audit Process Sub-Group: Generators of Data (IPCT)

Related Studies: 1, 2

Interview Schedule	Probe No.	Key themes to cover	Study/Aim
		STUDY 1	
4	1	Describe the Audit process. How does ICT see the actual process? (*Burden? Data Accuracy?*)	S1/A1: Identify Tools Used S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
4	2	Discuss how ICT was trained in Hand Hygiene compliance Auditing (*complicated? Adequate?*)	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting S1/A3: Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved
4	3	Does ICT2 have views on the current Audit Tool as a mechanism for Monitoring/Measuring (and Feedback) Hand Hygiene compliance (*unrelated to Hand Hygiene Compliance – 5 Moments - Training?*)	S1/A3: Clarify whether healthcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help?
		STUDY 2	
4	4	With regard to the current ICNA "Observed" Audit section (e.g. questions 32a-g)? are any of these particularly difficult to comply with? For performing Audit? For performing Hand Hygiene? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with

5	7	Description of an "Ideal Scenario" – how could the Measurement/Monitoring (and feedback) of Hand Hygiene Compliance be achieved in order to improve adherence (to the 5 Moments)?	n/a
5	8	Current knowledge of Hand Hygiene (Monitoring/Measuring/Feedback) technologies available – personal view (*give examples to aid discussion*)	n/a
5	9	View of technology for "5 Moments" compliance – any (strong) views on individual moments that should/should not be considered?	S2/A4: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of hand hygiene compliance in their setting? S2/A5: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?
5	10	View of anonymity in technology	n/a
5	11	Revisit "Ideal Scenario" (*if technology was not previously mentioned, Anonymity if not previously mentioned*)	n/a

Interview Schedule 5: Modern Matrons from UHP Wards

Audit Process Sub-Group: Recipients of Feedback (Modern Matrons/Ward Managers)

Related Studies: 1, 2

Interview Schedule	Probe No.	Key themes to cover	Study/Aim
		STUDY 1	
5	1	Discuss MM Hand Hygiene training experience (*received? 5 Moments? Adequate?*)	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
5	2	Discuss how MM was trained/informed of Hand Hygiene compliance Auditing – especially how to interpret Feedback data (*what are they aware of? Explicitly told? Knowledge of reasons behind it? Satisfied?*)	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored within an NHS acute setting
5	3	How does MM use the Feedback received from the Audit process? (*Regularly? When able? What limitations? Implication of 'closing the loop'*)	S1/A2: Understand/Portray h nd hygiene compliance is curren measured/monitored within 5 acute setting
5	4	Does MM have views on the current Audit Tool as a mechanism for Monitoring/Measuring (and Feedback) Hand Hygiene compliance (*unrelated to Hand Hygiene Compliance – 5 Moments - Training? Data Accuracy?*)	S1/A3: Clarify whether healt professionals consider this pr to be a 'burden' AND whether they t has the potential to be improved S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help? S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
		STUDY 2	
5	5	With regard to the current ICNA "Observed" Audit section (e.g. questions 32a-g)? are any of these particularly difficult to comply with (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with
5	6	With regard to the WHO 5 "Moments" are any of these particularly difficult to comply with? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with

6	6	Description of an "Ideal Scenario" – how could the Measurement/Monitoring (and feedback) of Hand Hygiene Compliance be achieved in order to improve adherence (to the 5 Moments)?	n/a
6	7	Views of Hand Hygiene (Monitoring/Measuring/Feedback) technologies available – (*give examples to aid discussion*)	n/a
6	8	View of technology for "5 Moments" compliance – any (strong) views on individual moments that should/should not be considered?	S2/A4: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of hand hygiene compliance in their setting? S2/A5: Reactions to technology – do current healthcare professionals view existing innovations as useful for measurement/monitoring/feedback of compliance with regard to WHO 5 Moments?
6	9	View of anonymity in technology	n/a
6	10	Revisit "Ideal Scenario" (*if technology was not previously mentioned, Anonymity if not previously mentioned*)	n/a

Interview Schedule 6: HP from UHP Wards

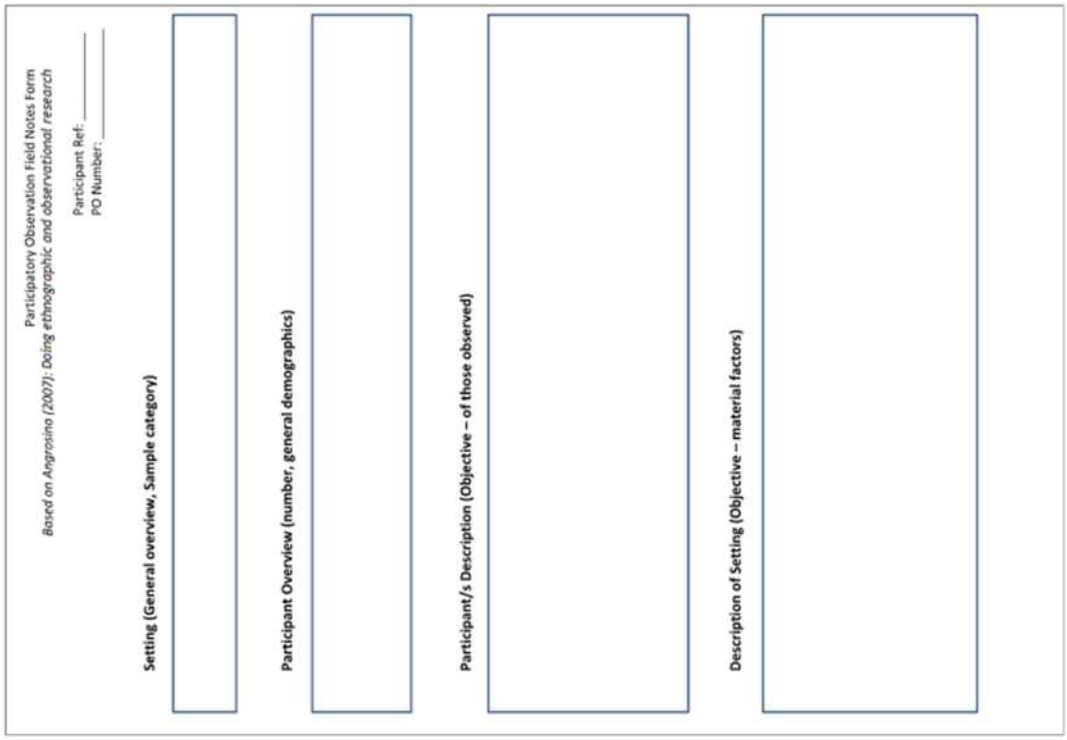
Audit Process Sub-Group: Subjects of Observation (Ward-Based Healthcare Professionals)

Related Studies: 1, 2

Interview Schedule	Probe No.	Key themes to cover	Study/Aim
		STUDY 1	
6	1	Discuss HP Hand Hygiene training experience (*received? 5 Moments? Adequate?*)	S1/A2: Understand/Portray how hand hygiene compliance is currently measured/monitored an NHS acute setting
6	2	Discuss how HP was made aware of Hand Hygiene compliance Auditing (*what are they aware of? Explicitly told? Knowledge of reasons behind it?*)	S1/A2: Understand/P how hand hygiene compliance i ntly measured/monitored an NHS acute setting
6	3	Does HP have views on the current Audit Tool as a mechanism for Monitoring/Measuring (and Feedback) Hand Hygiene compliance (*unrelated to Hand Hygiene Compliance – 5 Moments - Training? Data Accuracy?*)	S1/A3: Clarify whethe hcare professionals consider this process to be a 'burden' AND whether they think it has the potential to be improved S1/A4: Clarify whether healthcare professionals consider the tool being used (ICNA) is exacerbating the 'burden' e.g. would a change of tool help? S1/A5: Clarify whether healthcare professionals have concerns over data accuracy
		STUDY 2	
6	4	With regard to the current ICNA "Observed" Audit section (e.g. questions 32a-g)? are any of these particularly difficult to comply with (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2a: Clarify if healthcare professionals consider any of the ICNA (2004) Hand Hygiene Audit Tool observational questions (i.e. 32a-g) particularly difficult to monitor, measure, feedback on, or comply with
6	5	With regard to the WHO 5 "Moments" are any of these particularly difficult to comply with? (*if no/unsure – are there scenarios where other people/self could imagine it would be hard/er?*)	S2/A2b: Clarify if healthcare professionals consider any of the WHO 5 Moments particularly difficult to monitor, measure, feedback on, or comply with

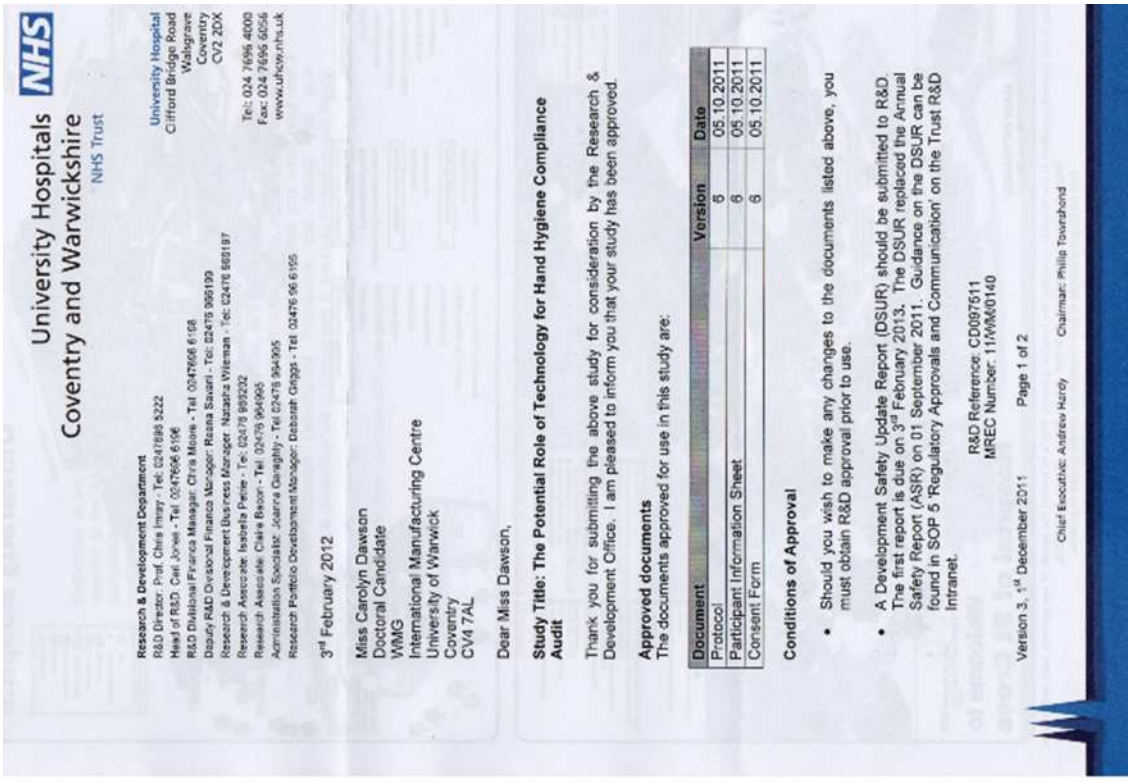
Appendix 3e: Participatory Observation Form

A purpose designed form was used for the ten participatory observation session carried out for Study 1, based on guidance from Angrosino (2007).



Appendix 3f: Ethics Documentation

Approval was gained for the research from the R & D department at the Case Study Site:



University Hospitals Coventry and Warwickshire NHS Trust

NHS

Research & Development Department
R&D Director: Prof. Chris Imray - Tel: 02476885222
Head of R&D: Ceri Jones - Tel: 02476866166
R&D Divisional Finance Manager: Chris Moore - Tel: 02476866168
Deputy R&D Divisional Finance Manager: Reena Savani - Tel: 02476 966199
Research & Development Business Manager: Natasha Wileman - Tel: 02476 966197
Research Associate: Isabella Perrie - Tel: 02476 965232
Research Associate: Claire Bacon - Tel: 02476 964965
Administration Specialist: Joanna Geraghty - Tel: 02476 964965
Research Portfolio Development Manager: Deborah Griggs - Tel: 02476 96 6195

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www.uhcw.nhs.uk

3rd February 2012

Miss Carolyn Dawson
Doctoral Candidate
WMG
International Manufacturing Centre
University of Warwick
Coventry
CV4 7AL

Dear Miss Dawson,

Study Title: The Potential Role of Technology for Hand Hygiene Compliance Audit

Thank you for submitting the above study for consideration by the Research & Development Office. I am pleased to inform you that your study has been approved.

Approved documents
The documents approved for use in this study are:

Document	Version	Date
Protocol	6	05.10.2011
Participant Information Sheet	6	05.10.2011
Consent Form	6	05.10.2011

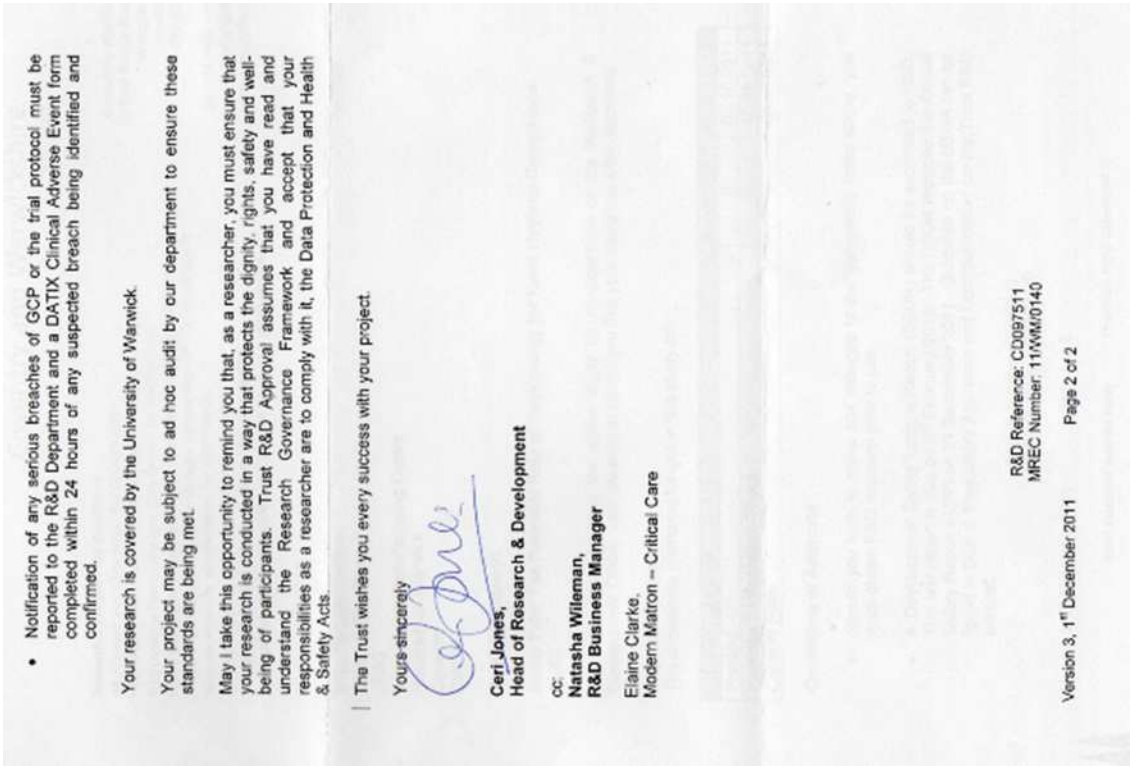
Conditions of Approval

- Should you wish to make any changes to the documents listed above, you must obtain R&D approval prior to use.
- A Development Safety Update Report (DSUR) should be submitted to R&D. The first report is due on 3rd February 2013. The DSUR replaced the Annual Safety Report (ASR) on 01 September 2011. Guidance on the DSUR can be found in SOP 5 'Regulatory Approvals and Communication' on the Trust R&D Intranet.

R&D Reference: CD097511
MREC Number: 11/WM/0140

Version 3, 1st December 2011 Page 1 of 2

Chief Executive: Andrew Hardy Chairman: Philip Townshend



- Notification of any serious breaches of GCP or the trial protocol must be reported to the R&D Department and a DATIX Clinical Adverse Event form completed within 24 hours of any suspected breach being identified and confirmed.

Your research is covered by the University of Warwick.

Your project may be subject to ad hoc audit by our department to ensure these standards are being met.

May I take this opportunity to remind you that, as a researcher, you must ensure that your research is conducted in a way that protects the dignity, rights, safety and well-being of participants. Trust R&D Approval assumes that you have read and understand the Research Governance Framework and accept that your responsibilities as a researcher are to comply with it, the Data Protection and Health & Safety Acts.

The Trust wishes you every success with your project.

Yours sincerely

Ceri Jones,
Head of Research & Development

cc:
Natasha Wileman,
R&D Business Manager

Elaine Clarke,
Modern Matron – Critical Care

R&D Reference: CD097511
MREC Number: 11/WM/0140

Version 3, 1st December 2011 Page 2 of 2

Permission was also granted by the National Research Ethics Service (NRES), via the West Midlands Committee – Staffordshire:

NHS

NRES Committee West Midlands - Staffordshire

Prospect House
Fishing Line Road
Redditch
Worcestershire
B97 6EW

Telephone: 01527 582535

26 September 2011

Dr Laura Martinez-Solano
RCUK Research Fellow
University of Warwick
IMC Building
University of Warwick
Coventry
CV4 7AL

Dear Dr Martinez-Solano

Study title: **What are the views of Healthcare-workers and members of the Public with regard to technology to improve Hand Hygiene compliance in an acute NHS setting?**

REC reference: **11/WM/0140**

Thank you for your letter of 29 August 2011, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair in consultation with two members.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

NHS sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations

Additional conditions of the favourable opinion

The reviewer's recommendation that the researcher is experienced or trained in running focus groups to be complied with.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Evidence of insurance or indemnity		01 August 2010
Investigator CV		31 March 2011
Letter of invitation to participant	4	14 February 2011
Other: Student cv		08 April 2011
Other: Clarificatio of Methocology for Ethics REC	2	08 September 2011
Participant Consent Form	5	01 June 2011
Participant Information Sheet: Compliance in an acute NHS Setting	5	01 March 2011
Participant Information Sheet: Healthcare worker & public views on hand hygiene compliance in acute NHS setting	7	20 June 2011
Protocol	5	12 April 2011
REC application	3.0	12 April 2011
Referees or other scientific critique report	1	20 March 2011
Referees or other scientific critique report		28 June 2011
Response to Request for Further Information		29 August 2011

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating

The attached document *'After ethical review – guidance for researchers'* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

Further information is available at National Research Ethics Service website > After Review

11/WM/0140 **Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project

Yours sincerely

Jenny Tyers (Mrs) for and on behalf of
Dr Kathryn Kinmond
Chair

Email: jenny.tyers@westmidlands.nhs.uk

Enclosures: *"After ethical review – guidance for researchers"*

Copy to: *Mr Peter Hedges*

Miss Carolyn Dawson
IMC Building
University of Warwick
Coventry
CV4 7AL

Ms Ceri Jones
R & D Department,
University Hospitals Coventry & Warwickshire NHS Trust

The regulation changes associated with the harmonised edition of GAfREC (September, 2011) meant that this permission was no longer required, and further updates to the NRES committee were not necessary for the duration of the research, as confirmed in January 2012:

NHS
Health Research Authority
NRES Committee West Midlands - Staffordshire
Prospect House
Fishing Line Road
Redditch
Worcestershire
B97 6EW
Tel: 01527 582535
Fax: 01527 582540

24 January 2012

Miss Carolyn Dawson
Doctoral Candidate
WMG
International Manufacturing Centre
The University of Warwick
Coventry
CV4 7AL

Dear Miss Dawson

Study title: **What are the views of Healthcare-workers and members of the Public with regard to technology to improve Hand Hygiene compliance in an acute NHS setting?**

REC reference: **11/WM/0140**

Thank you for your letter dated 06 January 2012 with details of a change in the research study design.

Following the publication of GAfREC 2 in September 2011 we are no longer required to monitor your study as the participants are now Healthcare Workers only (and do not include members of the public). We acknowledge your removal of public participant involvement.

Please continue to keep your sponsor and local R&D Trust informed of any progress/changes to your study.

11/WM/0140: **Please quote this number on all correspondence**

Yours sincerely

Mrs Jenny Tyers
Committee Co-ordinator

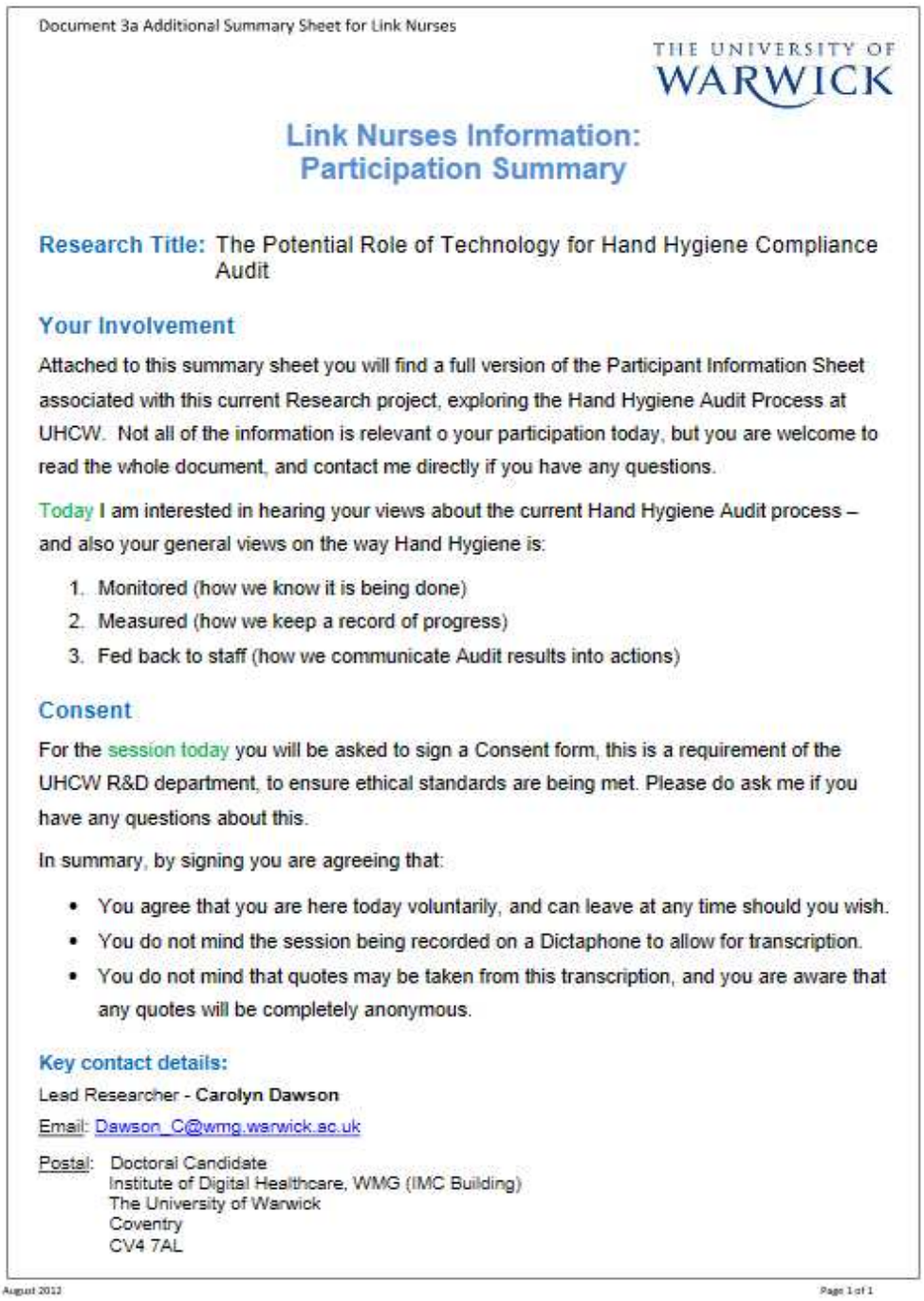
Email: jenny.tyers@westmidlands.nhs.uk

A Research Ethics Committee established by the Health Research Authority

Appendix 4

Appendix 4a: Participant Information Document: Link Nurses

A purpose designed information sheet was produced for the Link Nurse meeting held to discuss themes related to Study 1. This preceded the collection of informed consent.



Document 3a Additional Summary Sheet for Link Nurses

THE UNIVERSITY OF WARWICK

Link Nurses Information: Participation Summary

Research Title: The Potential Role of Technology for Hand Hygiene Compliance Audit

Your Involvement

Attached to this summary sheet you will find a full version of the Participant Information Sheet associated with this current Research project, exploring the Hand Hygiene Audit Process at UHCW. Not all of the information is relevant o your participation today, but you are welcome to read the whole document, and contact me directly if you have any questions.

Today I am interested in hearing your views about the current Hand Hygiene Audit process – and also your general views on the way Hand Hygiene is:

1. Monitored (how we know it is being done)
2. Measured (how we keep a record of progress)
3. Fed back to staff (how we communicate Audit results into actions)

Consent

For the session today you will be asked to sign a Consent form, this is a requirement of the UHCW R&D department, to ensure ethical standards are being met. Please do ask me if you have any questions about this.

In summary, by signing you are agreeing that:

- You agree that you are here today voluntarily, and can leave at any time should you wish.
- You do not mind the session being recorded on a Dictaphone to allow for transcription.
- You do not mind that quotes may be taken from this transcription, and you are aware that any quotes will be completely anonymous.

Key contact details:

Lead Researcher - **Carolyn Dawson**

Email: Dawson_C@wmg.warwick.ac.uk

Postal: Doctoral Candidate
Institute of Digital Healthcare, WMG (IMC Building)
The University of Warwick
Coventry
CV4 7AL

August 2012 Page 1 of 1

Appendix 4b: Prompts used in Interviews

Participants were shown paper print outs of slides used on the laptop presentation, showing the Current State Map (Figure A-4) and observation questions from the ICNA audit tool (points 32a-g) and WHO 5 Moments (Figure A-5).

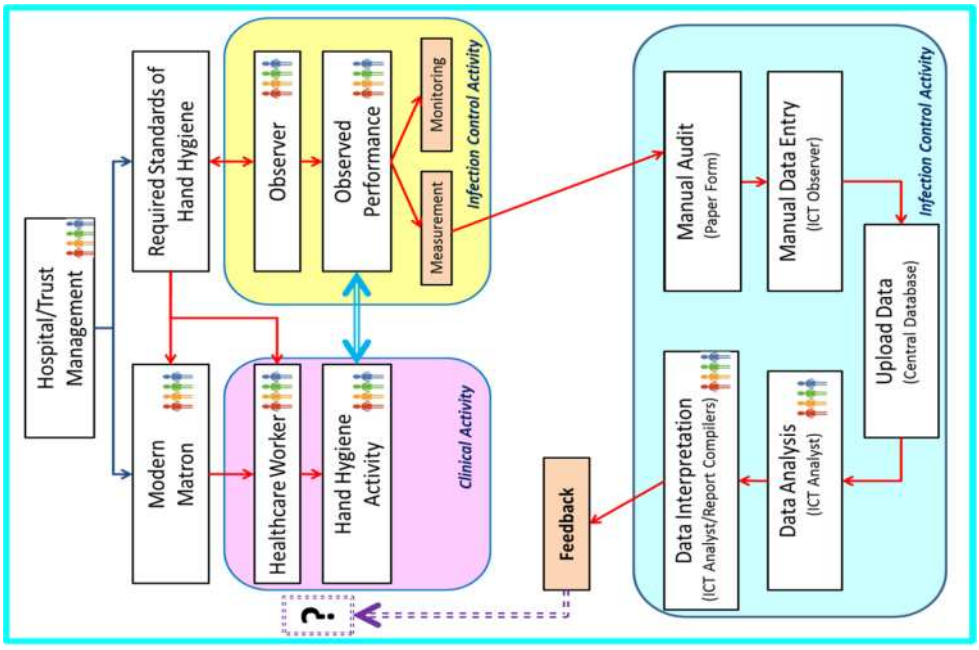


Figure A-4: Current State Map, allowing discussion of the participant's view of their role in the audit process, and their view of current strengths/weaknesses.

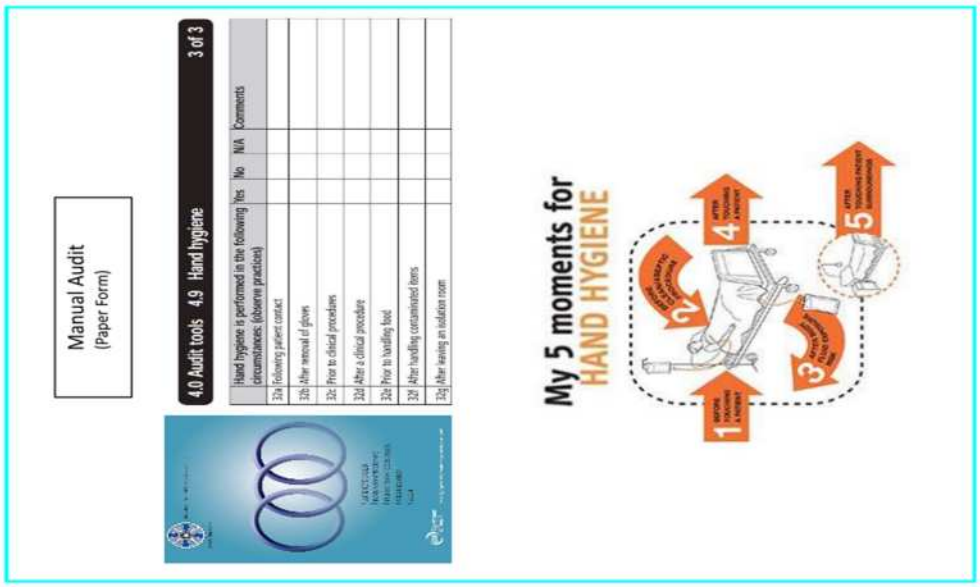


Figure A-5: An extract from the ICNA (2004) audit tool and a WHO 5 Moments example were used to discuss how hand hygiene was both measured and taught at the case study site

Appendix 4c: Effective Care Training Day: Notes

Observational notes were taken during an "Effective Care" training day help by the IPCT at the case study site, a typical event for new starters, introducing them to Infection prevention themes. These notes allowed insight into the level of education available at the case study site, providing context alongside issues raised in interviews and during the participatory observation sessions.

Hand Hygiene Training Session
Non-Participatory Observation

Date: 25th June 2012

Event: "Effective Care" Training Session – New Starters

Location: Seminar Room, Clinical Science Building (CSB), UHCW

Attendees: 2 x ICT Members, 12-15 new HCA starters (15 by 30minutes in) with on-ward experience of between 6 weeks and 1 year. Individuals identified themselves as being HCA (14) or a Porter (1), with backgrounds including working in fast food, community care and nursing. Some attendees described themselves as Support Workers – this was clarified later by the ICT members as falling into the HCA role. NVQ training was being undertaken by at least some of those attending the training day.

Format: Morning session hosted by ICT, split into 2 sections; 1. Aseptic Technique and 2. Sharps, Environment and Hand Hygiene.

Section 1: Aseptic Technique

ICT Nurse carried out semi-formal presentation on the topic of Asepsis, with opportunities for attendees to interrupt to ask questions, and with 'test-your-knowledge' segments, going over the key issues throughout the talk.

Key topics:

1. What is Asepsis?
   (Lister, Florence Nightingale, picture of original amputation)
2. Why is Asepsis important?
   (Direct/In-Direct Transmission, Endo/Exogenous Infections, Risk Assessment/Patient Susceptibility)
3. Gardner and Peel (1998) definition of Asepsis
4. Explanation of Aseptic Procedure
   (Detergent then alcohol wipe, because alcohol doesn't penetrate organic matter; use of PPE (i.e. apron), importance of 2-way protection)

Attendees asked to volunteer to 'Show Hand Hygiene' – a few attendees gave some feedback, general consensus that they 'know it, and just do it'. Feedback from IPCT Nurse that there should always be Posters at each Hand Hygiene station, and if followed, correct Hand Hygiene technique (i.e. Aylifle) will always be assured.

Attendee volunteered information re own location (Gynaecological Clinic xxxx) that dispensers were often empty – given information as to how to deal with this (i.e. inform Ward stores link, ISS responsible for dispensers).

Explanation given as to Non-Touch technique e.g. parts going 'into' Patients must never be touched; e.g. end of syringe, catheter.

Q & A with attendees – asked to come up with examples of Aseptic Procedures – to ensure understanding. Examples given included IV line set up and maintenance, Catheter care, and inserting drains.

A second video, "Urinalysis" – again featuring the ICT from UHCW, here in a scenario where environmental contamination was occurring through poor hand hygiene. Attendees were asked about familiarisation with the WHO "5 Moments", with general consensus that they recognised the poster, but very few knew (or volunteered) an ease at naming all 5 Moments. ICT Members provided all attendees with credit card sized reminder versions of the "My 5 Moments for Hand Hygiene" promotional poster, and explained the importance of Hand Hygiene at these critical areas of infection cross-contamination risk. Also, at this opportunity, the importance of hand hygiene as a way to defend 'self' and family – with examples of Patients being carriers of bacteria all over the hospital (e.g. smoking, taking equipment out with them, touching doors, lift controls etc) and the Healthcare Professionals potentially being carriers to their own friends and families. This example was directly highlighted in the interview given by this ICT Member (*see interview 001*).
A Q + A on 5 Moments followed the Urinanalysis video to assess understanding of the key points covered, and an emphasis was placed on understanding the Environmental space (i.e. Patient Zone) – that Hand Hygiene must be practised even if the Healthcare Professional has not directly touched the Patient. Such emphasis tied in well with the findings from the Observations, and from the Interviews (*Examples*).

A third video was used to demonstrate the Ayliffe technique – the 8-step correct hand hygiene procedure to ensure effective hand decontamination. The video had been made by a local secondary school, and was met with positive remarks from the group, who all felt it should be made available to public and staff alike, to highlight the ease of performing Hand Hygiene, and as a reminder.

Following this visual demonstration of Hand Hygiene, the Attendees were all invited to assess their own Hand Hygiene technique , using the GlowBox tool. Here, the individuals were all given a special hand cream to use, and asked to rub it into their hands, as if they were using and AHR. The cream, containing a UV sensitive element, absorbed quickly into the skin. Hands were then placed under the UV source in the GlowBox, so individuals could see the coverage; this tool both showed them what coverage they were getting with the AHR thechnique they were using, and more importantly, was then used to assess Hand Hygiene with Soap and Water. The group were then sent off to perform Hand Hygiene with Soap and Water, as if they were on regular clinical duties, and asked to return to the GlowBox. The cream can easily be removed by Soap and Water and physical rubbing – thus any left on the hands revealed by the GlowBox indicates inadequate Hand Hygiene, and represents potential contamination if it were, for example, bacteria. Each attendee was then able to see specific areas of Hand Hygiene weakness (e.g. between fingers, wrists), and could use this visual reference to improve future practice.

The session ended with the 'Quiz' – whereby attendees filled in a short sheet linked to the topics covered. Answers were gone through as a group, and a 'winner' was picked out of the hat and given a small prize, generating much amusement. All attendees were able to verbally answer/agree with each of the responses to the quiz, demonstrating that the session had been successful in imparting the required information.

Hand Hygiene Training Session
Non-Participatory Observation

Section 2: Sharps, Environment, Hand Hygiene

ICT Member (responsible for Hand Hygiene Trust wide) re-introduced themselves to group with a review of what had been covered, and what was to come. Explained that there would be a quiz, with a prize (!), generating laughter and a relaxed atmosphere within the group.

Key Issues:

1. Sharps
   Attendees were given a demonstration on Sharps Bins – correct procedure regarding construction, use and disposal. Rather than slides or pictures, a real bin was used (*as mentioned in interview with the ICT Member, see PP001 Interview*).

2. Auditing
   ICT Member explained own role, and the process and purpose of IC Audits. Detail given on what was expected (normal behaviour, to the standard trained) and how feedback would be given (at the time - so you can know what is done right, what needs changing – and through the report system).

3. Cleaning Fluid

4. Explanation and demonstration as to the use of Tristel disinfectant
   Real pack of Tristel Fuse disinfectant used to demonstrate how to make up solution required for disinfecting in-ward equipment (*as required by those featured in Participatory Observation*). Attendees were asked if they knew how this was done, and a volunteer was selected to demonstrate to the group.

5. Machine Safety
   Discussion as to proper use of Dekomed machine ('dishwasher' for bedpan decontamination) and 'Sluice Hopper'. Interactive debate, attendees highlighted individual problems experienced, misconceptions and challenged advice given; ICT member summarised correct procedures and took note of specific area within hospital where follow-up may be needed.

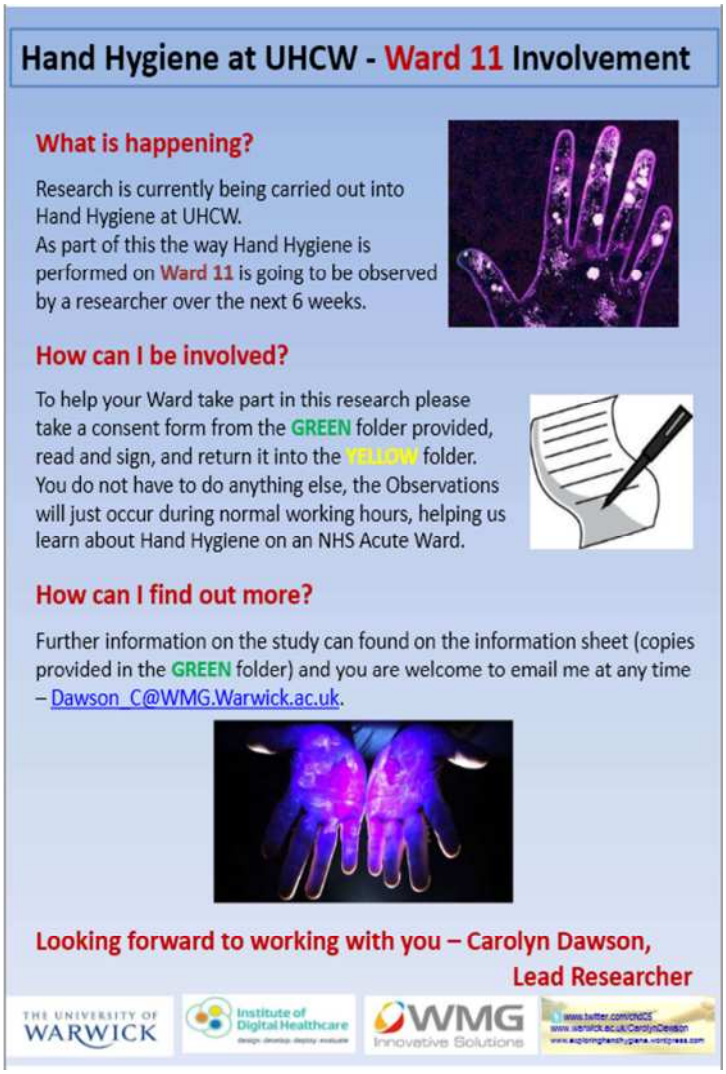
6. Sharps Injuries
   Attendees were asked how they would deal with a sharps injury e.g. needle stick injury – answers ranged in quality. ICT member gave correct procedure, and used a repeat test/re-test procedure to ensure the steps had been understood.

The session was then paused to watch a short (3-5minute) video "The Vomiting Patient" – a training video created by the IPCT some years previously, which showed a sketch representing poor care standards carried out by an HCA. The ICT Member paused the video, and the attendees were asked to comment on what actions they could spot which were dangerous, and what behaviours should have been carried out instead. The video was then continued, and a summary was shown, confirming the errors made and actions that should have been taken.
The video was entertaining, as it featured the two ICT members carrying out the morning's training, and generated a high level of discussion between, and from, attendees.

Appendix 5

Appendix 5a: Participant Information Sheet: Ward 11 (Study 3)

A specific flyer was produced to inform and invite participants from the chosen location for Study 3 (cardio-thoracic unit). Participation was facilitated by the Ward Manager.



Appendix 5b: Inherent/Elective scores: Context, Main category, and Source

Each data point was assigned a context, based on the field note commentary, a main category, based on the framework designed for the study (Table 7-5), and a source, which linked it to either the original literature of Whitby et al. (2006), the ICNA tool, or the WHO 5 Moments.

Period	Area	Inherent	Elective	Context	Main Category	Source
AM	Area 1 A		0	Before Patient Contact (Checking Patient wristband)	Carrying out observations	ICNA
AM	Area 1 A	1		After Handling Soiled Linen	Handling Soiled Linen	ICNA
PM	Area 1 A		0	After Helping Patient Out of Bed	Helping Patient Sit up in Bed	ICNA
PM	Area 1 A	1		Helping change a Patient Bed - removing soiled lined to sluice room	Handling Soiled Linen	ICNA
PM	Step-Down	1		After removed gloves after Cleaning used Commode (with gloves on) HH S/W	after emptying a soiled bed pan;	Whitby
PM	Step-Down		1	After removing gloves, apron, (after cleaning Patient Equipment - drip stand) HH S/W	After Removal of Gloves	ICNA
AM	Step-down		0	After touching Patient Equipment (moving communal Ward equipment)	after touching a patient's furniture;	Whitby
AM	Step-down	1		Helped remove dirty lined from Patient Zone to sluice room	Handling Soiled Linen	ICNA
PM	Step-Down		0	After Touching Patient Environment (Patient Curtains) - to putting gloves on	after touching a patient's furniture;	Whitby
PM	Step-Down	1		After Touching Soiled Lined (HH S/W)	Handling Soiled Linen	ICNA
AM	Step-Down	1		Before checking IV catheter (Hand)	Setting up an IV Line	ICNA
AM	Step-Down		0	Before Entering Side Room (Patient Area) - contact with patient occuring afterwards (touching hand)	Before Patient Contact	5 Moment
PM	Step-Down		0	After Touching Patient Surroundings (bedside table)	after touching a patient's furniture;	Whitby
PM	Area 1 A	1		After Handling Soiled Linen	Handling Soiled Linen	ICNA
AM	Area 1 A		1	After touching Patient Equipment communal Ward Blood Pressure monitor)	after touching a patient's furniture;	Whitby
AM	Area 1 A	1		After Handling Soiled Linen	Handling Soiled Linen	ICNA
AM	Step-Down	1		After handling clean bed pans in sluice room (GEL)	Emotional Driver	Whitby
AM	Step-Down		0	Before Putting Gloves on	Before Glove Use	PPE
AM	Step-Down		1	After touching Patient Equipment (Patient Bed)	after touching a patient's furniture;	Whitby
PM	Step-Down	1		Before Removal of IV - HH S/W	Setting up an IV Line	ICNA
AM	Area 1 B	1		After Intimate Washing of Patient	after touching a patient's groin; after touching a patient's armpit	Whitby
AM	Area 1 B		1	After Perorming Patient Observations (Blood Pressure/Temperature)	after taking a patient's temperature;	Whitby
AM	Area 1 B	1		After helping Patient with a Bed Bath (intimate)	after touching a patient's groin; after touching a patient's armpit	Whitby
AM	Area 1 B		1	After touching Ward Equipment (Drug Trolley)	after touching a patient's furniture;	Whitby
PM	Area 1 A		0	After Touching Patient Surroundings (Patient Bed)	after touching a patient's furniture;	Whitby
PM	Area 1 A	1		After handling clean Bed Pan	Emotional Driver	Whitby
PM	Step-Down		0	After touching Patient Equipment (ECG machine)	after touching a patient's furniture;	Whitby
PM	Step-Down	1		After handling dirty Linen	Handling Soiled Linen	ICNA
PM	Step-Down		0	After moving Patient Belongings	after touching a patient's furniture;	Whitby
PM	Step-Down	1		After Setting up an IV Line	Setting up an IV Line	ICNA
AM	Bay 16-20		1	After performing Patient Observations (Blood Presure/Temps)	after taking a patient's temperature;	Whitby
AM	Bay 16-20	1		After leaving Nurses station and Entering Patient Zone (and Touching Patient)	Manipulating a Urinary catheter	ICNA
PM	Area 1 B		0	Changing a Wound Dressing (Behind Curtain) HH S/W	Before Patient Contact	5 Moment
PM	Step-Down	1		Removal of dirty linen from Patent in side room (HH S/W in sluice room)	Changing a dressing	ICNA
PM	Step-Down		0	Before Putting Gloves on	Handling Soiled Linen	ICNA
AM	Step-Down	1		After Removing Catheter	Before Glove Use	PPE
AM	Step-Down		0	After Touching Patient Environment (Patient Table/Chair)	after changing a urine bag;	Whitby
PM	Step-Down		1	Before entering Patient Area contact with patient occuring afterwards (helping get comfortable)	after touching a patient's furniture;	Whitby
PM	Step-Down	1		Before manipulating Catheter/IV Lines	Before Patient Contact	5 Moment
					Setting up an IV Line	ICNA

Appendix 5c: Study 3: Data Collection Sheet

Study 3 data was collected using a purpose designed form which was kept as neutral as possible to try to reduce the potential of bias occurring should healthcare professionals see it during the time spent within the clinical area. Therefore no reference to Hand Hygiene, Inherent, Elective or any of the specific activities categorised in each group were included. Six spaces were given for each participant to record hand hygiene behaviour (Yes/No) when carrying out both Group 1 (Inherent) and Group 2 (Elective) clinical activities. Additional space was given to record the type of activity and any additional comments. A sample of this form is shown below:

PP No	Group 1	Y	N	Group 2	Y	N
1						
2						
3						
4						
5						

Appendix 6

Appendix 6a: Dissemination Activities (Summary)

Progress and findings from this research has been shared at a number of national and international conferences, and submitted for review to peer reviewed journals.

Peer Reviewed Conferences

To "Urgh" is Human… Exploring Inherent and Elective Hand Hygiene Triggers: A pilot study in the NHS - Oral presentation at Infection Prevention 2013, London, UK, 30th September-2nd October 2013.

Technologies to measure hand hygiene: examining the incorporation of the World Health Organisation (WHO) 5 moments – Poster presented at the International Conference on Prevention and Infection Control, Geneva, Switzerland, 25-28th June 2013.

Why do you wash your hands? Does the solution to hand hygiene compliance lie in understanding different types of hand hygiene behaviour – inherent and elective? – Poster presented at Twelfth Congress of the International Federation of Infection Control, Zagreb, Croatia, 10th-13th October 2012.

Exploring Human Behaviour and Technology in NHS Hand Hygiene Auditing – Poster presented at Infection Prevention 2012, Liverpool ACC, UK, 1st-3rd October 2012.

The Potential Role of Technology to Improve Hand Hygiene Auditing and prevent Hospital Acquired Gastrointestinal Infections – Poster presented at Health Protection Agency Conference 2012, Warwick University, UK, 11th-12th September 2012.

Peer Reviewed Papers

Dawson, C. H. and Mackrill, J. B. (2014) Review of Technologies available to improve hand hygiene compliance – Are they Fit-For-Purpose? Journal of Infection Prevention.*(accepted pending minor revisions)*

Dawson, C. H. Healthcare Professional views on the meaning of data produced by Hand Hygiene auditing. Journal of Infection Prevention. (*under review*)

Dawson, C. H. Developing a framework to identify clinical activities at risk of poor hand hygiene compliance. Journal of Hospital Infection (*in preparation*)

Dawson, C. H. A pilot study investigating the influence of clinical activity type on the likelihood of hand hygiene being performed. Journal of Hospital Infection (*in preparation*)

Dawson, C. H. A Framework for Developing Quality Processes: The importance of Healthcare Professional Involvement for Success. Journal of Infection Prevention. (*in preparation*)

Dawson, C. H. Healthcare Professionals views on technology to aid hand hygiene measurement: a case study. Journal of Hospital Infection. (*in preparation*)