An exploration of the use of theory and visualisation in behaviour change interventions to help healthcare staff prevent and control healthcare-associated infections.

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AN EXPLORATION OF THE USE OF THEORY AND VISUALISATION IN BEHAVIOUR CHANGE INTERVENTIONS TO HELP HEALTHCARE STAFF PREVENT AND CONTROL HEALTHCARE-ASSOCIATED INFECTIONS

KONSTANTINOS TSATTALIOS

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Abstract

Changing healthcare staff's behaviours is of paramount importance in improving infection prevention and control (IPC) and decreasing healthcare-associated infections (HAIs). Thus, many supportive interventions have been developed in pertinent areas such as hand hygiene (HH). The concepts of theory and visualisation in behaviour change research are well described and embraced across the social sciences as they provide rigorous and innovative interventional solutions. However, the use of each of these concepts within interventions in IPC and HAIs related research has not been systematically researched and neither has their use in combination. The current thesis thus aimed to explore this field in depth with a view to developing evidence-based recommendations for designing behaviour change interventions combining theory and visualisation.

The study comprises a sequential multimethod pragmatic inquiry. This commenced with conducting two separate integrative literature reviews exploring the wider context of theory-based and visualisation-centred interventions respectively, in the field of IPC and HAIs. The reviews addressed gaps in relation to what theories and visualisation have been used in pertinent interventions, the structure and application of these and which seem to work. They raised however further questioning related, for example, to which intervention parts work better than others and how and why parts or whole interventions work.

The above questioning formed the basis for conducting a Delphi study with a participating international panel of key experts (*n*=18) in the fields of IPC, HAIs, intervention development, theory and/or visualisation. Through 3 questionnaire and survey rounds the expert panel provided insights to questions (round 1) and were asked to rank subsequent related statements according to the degree of their agreement (rounds 2 and 3). The experts' responses provided sets of theories and visualisations along with other important intervention elements (e.g. behaviour change techniques) that could be prioritised when considering combinations to use for developing focal interventions (i.e., targeted to specific behaviours of individuals or teams) and systems-based interventions (i.e., targeted to whole healthcare organisations).

Finally, four focus groups with nurses and infection control staff (*n*=18) from two Scottish Health Boards aimed to obtain staff opinions and perspectives regarding IPC based on their clinical experiences. Participants were, also presented with selected recommendations from the Delphi study and were asked to comment on them and make further suggestions. Findings indicate that posters are less effective and that work and time pressure as part of clinical practice should be considered when developing pertinent interventions. Taken together it was possible to formulate a menu of recommendations with their foundational basis on the combination of participatory theoretical approaches and dynamic forms of visualisation.

This research provides novel insight into the role of theory and visualisation in HAIs and IPC practice. The explicit combination of theory and visualisation has been demonstrated to be very under-researched thus these findings contribute original knowledge and offer value for practice, education and research.

Keywords: infection prevention and control, healthcare-associated infections, behaviour change, theory, visualisation, integrative literature review, Delphi technique, focus group

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CONFERENCE POSTER PRESENTATIONS

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PUBLICATIONS

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List of abbreviations

ABHR	Alcohol-Based Hand Rub
ADU	Ambulatory Dialysis Unit
BASNEF	Behaviour, Attitude, Subjective Norms, and Enabling Factors
BCT	Behaviour Change Technique
CASP	Critical Appraisal Skills Programme
CD	Compact Disc
CDC	Centers for Disease Control and Prevention
CLASBI	Central Line-Associated Bloodstream Infection
CUSP	Comprehensive Unit-Based Safety Program
EBP	Evidence-Based Practice
EBCD	Experience-based Co-design
ECDC	European Centre for Disease Prevention and Control
FLO	Front Line Ownership
HAIs	Healthcare-Associated Infections
HBM	Health Belief Model
HH	Hand Hygiene
HoB	Head of Bed
ICU	Intensive Care Unit
IR	Integrative Review
ITU	Intensive Therapy Unit
IPC	Infection Prevention and Control
MRC	Medical Research Council
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
OR	Operating Room
PDSA	Plan-Do-Study-Act
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QATSDD	Quality Assessment Tool for reviewing Studies with Diverse Designs
QI	Quality Improvement
QI-MQCS	Quality Improvement Minimum Quality Criteria Set
RCT	Randomised Control Trial
RN	Registered Nurse
SERP	School Ethics Review Panel

SCT	Social Cognitive Theory
SIT	Social Influence Theory
SLT	Social Learning Theory
STS	Socio-Technical Systems
TDF	Theoretical Domains Framework
TPB	Theory of Planned Behaviour
TTM	Trans-Theoretical Model
UK	United Kingdom
VAP	Ventilator-Association Pneumonia
VRE	Vancomycin-Resistant Enterococci
WHO	World Health Organisation

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Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

1.1 Introduction to the Chapter

The focus of this doctoral study is on a triad of primary concepts namely, 'healthcare-associated infections – theory – and visualisation'. In this first introductory chapter of the thesis an overview of the concept of healthcare-associated infections (HAIs) will be provided. More specifically, it will be explained what HAIs are and why they pose a threat for the public on a national and international level. Then an overview of the ways that HAIs are managed will be presented with a focus on behavioural-based approaches and the importance of theory in the development of successful interventions. The value of visualisation approaches in intervention development and its potential usefulness in HAIs-related interventions will be presented. Finally, the current programme of research will be laid out outlining the thesis's aim and objectives, as well as its overall structure. It is important to note that the concepts of behaviour change and healthcare staff are also central concepts for the thesis. However, given the exploratory nature of the research, the focus on changing practice is not restricted exclusively to behaviour change (i.e., other wider considerations are included) and the focus on healthcare staff is primarily around nursing staff but not exclusively so.

1.2 Overview of healthcare-associated infections

Within this section the concept of HAIs is presented aiming to provide an account of its importance and the impact it has on patients, healthcare staff and the healthcare system.

1.2.1 The concept of healthcare-associated infections

HAIs pose a severe and persistent public health problem in developed (Revelas 2012) and developing (Yue et al. 2017) countries across the world. The World Health Organisation (WHO 2011) defines HAIs as those infections that affect primarily patients after their admission to a healthcare setting and during the process of care they receive. The quality of patient care is often tightly linked to HAIs as they are considered to be one of the most preventable complications among patients (Taplitz et al. 2017). Apart from patients, healthcare staff as well as family members visiting the clinical setting are also open to risk of HAIs when caring for patients (Barer and Irving 2018). With regards to terminology, HAIs are also sometimes referred to as 'hospital-acquired infections', and 'nosocomial infections' terms that have been used interchangeably across the literature. The term 'healthcare-associated infections' has been used throughout the current thesis.

1.2.2 Manifestation of healthcare-associated infections

A key point in relation to the definition of HAIs is that they are not infections acquired and manifested solely in the hospital setting, but in a wide range of healthcare-related settings. Such settings may include, for example, outpatient clinics, nursing care homes, private clinics, doctors' offices, and community health centers (WHO 2016). HAIs are typically not present or incubating on the patient at the time of a patient's admission and occur within 48 hours of admission even after discharge (Cardoso et al. 2014).

1.2.3 Sources of healthcare-associated infections

HAIs are the result of the presence of infectious and highly resistant pathogens that can be viral (e.g. hepatitis, influenza, rotavirus), bacterial (e.g. Acinetobacter, Clostridium Difficile (C. difficile*)*, Methicillin-resistant *Staphylococcus aureus* (MRSA), *Escherichia coli* (E. Coli) or fungal (e.g. candida albicans, aspergillus) (Khan et al. 2017). In addition, these pathogens can be either endogenous (i.e., residing and are colonised in the human body including the mouth, skin and gastrointestinal tract) or exogenous (i.e., pathogens from the external environment that gain entrance to the human body) (Diegel-Vacek and Ryan 2016).

1.2.4 Affected population and risk factors

As highlighted above, typically any individual involved in healthcare can acquire a HAI with patients being at particularly high risk. Although, any patient admitted to a healthcare-related setting is susceptible to acquiring HAIs, patients with weakened immune system, children and the elderly tend to be more prone to acquiring HAIs (Yallew et al. 2017).

Apart from patients' who are immunocompromised and age group, other risk factors for acquiring HAIs have been indicated including for example the patient's gender (i.e., higher prevalence among males) (Deptula et al. 2015), the type of healthcare setting (i.e., higher prevalence among large and teaching hospitals) (Deptula et al. 2015; Yallew et al. 2016), use of invasive devices (e.g. urinary catheter) (Phu et al. 2016) and any surgery undertaken prior to the patient's admission (Liu et al. 2016).

1.2.5 Common types of healthcare-associated infections

According to the most recent point prevalence survey of HAIs and antimicrobial use in European acute care hospitals published by the European Centre for Disease Prevention and Control (ECDC, 2013) five HAI types accounted for more than 80% of all HAIs. These were respiratory tract infections (23.5%; including ventilator-associated pneumonia and lower tract infections), surgical site infections (19.6%), urinary tract infections (19%), central line-associated bloodstream infections (10.7%) and gastro-intestinal infections (7.7%) (ECDC 2013).

1.2.6 The burden of healthcare-associated infections

The 'Quality standard' report published by NICE (2016) underscores that HAIs pose a serious public health threat leading to alarming morbidity and mortality rates as well as financial losses for the National Health Service (NHS). More specifically, according to the recently published 3rd Scottish national prevalence survey (Health Protection Scotland 2017) it is found that on average there is 1 patient with HAIs in every clinical ward in every hospital at all times with 55,500 estimated HAIs every year across Scottish hospitals. The survey, also, highlighted that hospitalised patients are older and sicker compared to the previous survey published in 2012 (Health Protection Scotland 2012) with urinary tract infections and respiratory tract infections (reference to pneumonia) as the most common identified HAIs. These HAIs were also identified as the most common types across English hospitals with MRSA and C. diff as the main pathogens leading to an estimated 9,000 deaths in hospital and primary care settings in the country (National Audit Office 2009). In terms of associated costs, it is estimated that the financial burden for the NHS is approximately £1 billion a year as a direct result of patients' prolonged stay at the hospital setting with £56 million additionally being incurred after their discharge from hospital (NICE 2012).

On an international level, according to a report on the burden of HAIs worldwide published by WHO (2011) the prevalence of HAIs ranges from as high as 12% in New Zealand to as low as 3.6% in Germany (figure 1.1). The UK is placed averagely amongst high-income countries at 9%. The report's findings reflected a mixed patient population suggesting a 7.6% HAIs prevalence rate on average among high income countries.

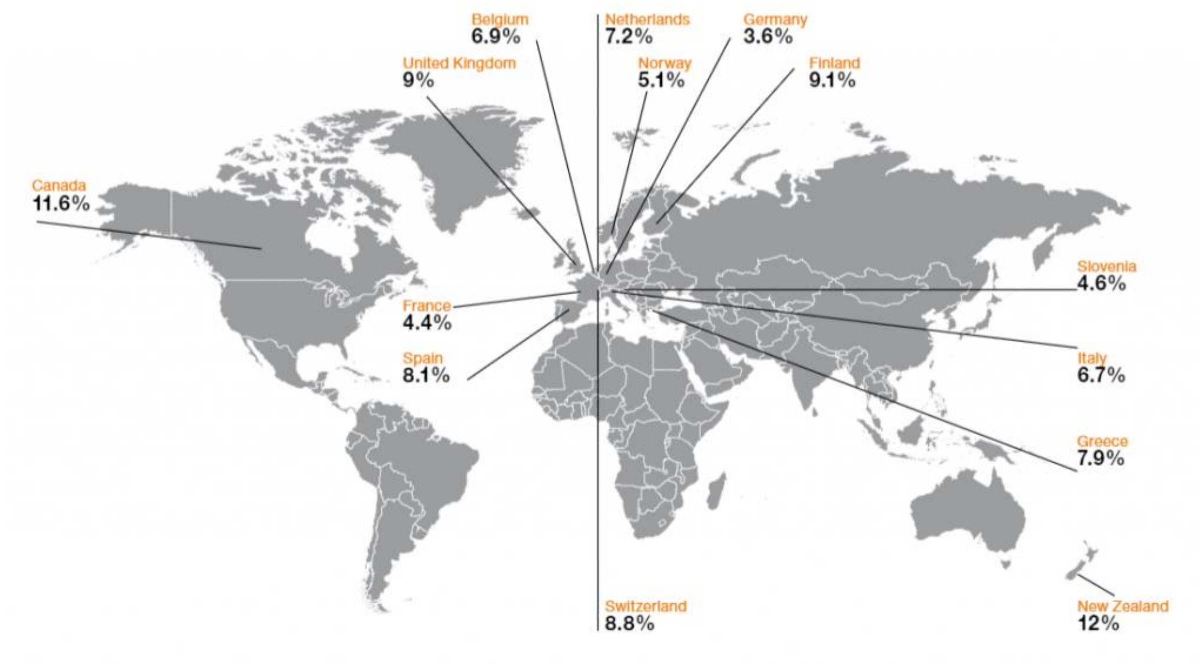

Figure 1.1 Prevalence of health care-associated infection in high-income countries between 1995-2010 (WHO 2011).

In relation to HAIs prevalence rates in developing countries, WHO (2011) characterised the overall picture of HAIs prevalence as 'fragmented'. More specifically, no data at all was available for the majority of the developed countries (66%) whereas scant information for the remaining countries was harnessed for further scrutiny. Of the reported findings it is evident that HAIs prevalence rates across developing countries are overall higher compared to developed countries ranging from 5.4% (lowest) in Mongolia to 19.1% (highest) in Albania. This range is interpreted as a 10.1% HAIs prevalence rate on average among low-, and middle-income countries (figure 1.2).

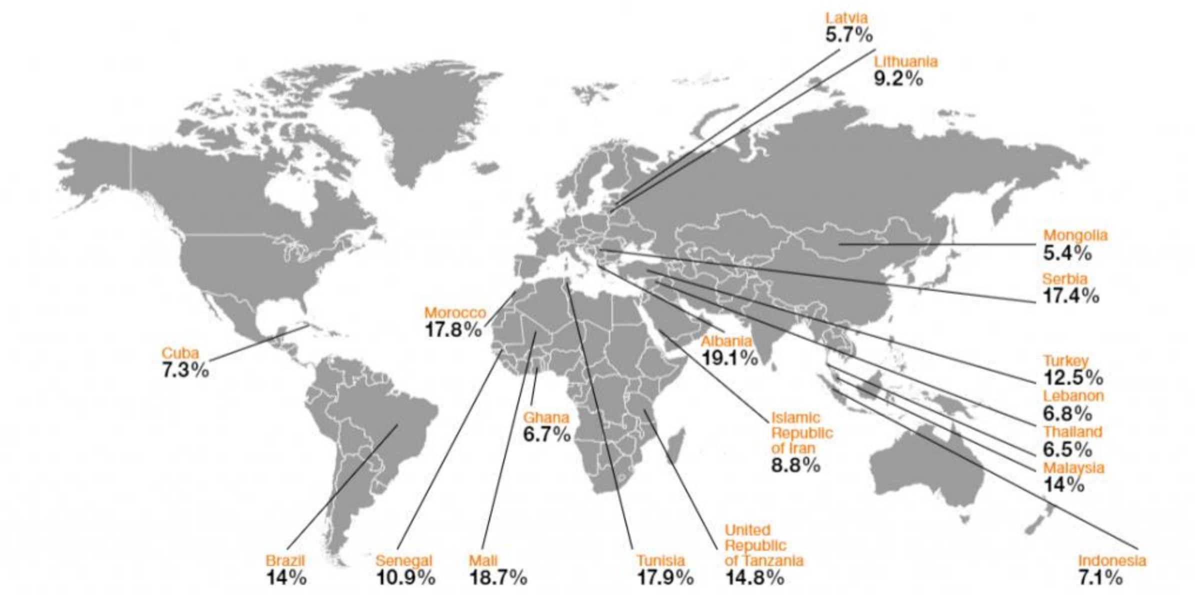

Figure 1.2 Prevalence of health care-associated infection in low- and middle-income countries between 1995-2010 (WHO 2011).

1.2.7 Antimicrobial resistance

The significance of the HAIs issue becomes even more worrying in the light of evolving antimicrobial resistance (AMR) (Sievert et al. 2013) along with WHO's warnings of a predicted 'post-antibiotic-era' in which simple infections or slight injuries could kill (WHO 2014). AMR refers to the presence of resistant pathogens, including bacteria and viruses, which are no longer susceptible to antimicrobials (Prestinaci et al. 2015). A WHO press release in 2017 entitled 'New antibiotics needed for 12 families of bacteria' underscores the need to further promote and guide research and development regarding new antibiotics in an attempt to manage the pathogens' evolving global resistance to antimicrobial medicines (WHO 2017). The presence of infections is the main indication for prescribing antimicrobials in human medicine. Thus, the prevention of infections is a key step towards rationally reducing antibiotic use (Mielke 2018).

Scientists such as microbiologists, clinical pharmacists and chemists (as well as scientists from similar disciplines) will shoulder a heavy responsibility over the next few years elucidating the context related to infection prevention and control (IPC) within which AMR evolves. However, other disciplines directly involved in healthcare may be able to contribute towards HAIs management in innovative ways as yet to be differentiated and understood. One such way is the understanding of human behaviour as a powerful, and rational method for improving IPC and reducing HAIs (Pittet 2004).

The significance of behaviour can be further appreciated considering the key role that 'person to person' transmission has in the spread of pathogens and thus HAIs (Weston, Hauck and Amlot 2018). Considering that specific behaviours in the context of HAIs and IPC can be very complex, such as hand hygiene (HH), the use of theory has been characterised as a promising tool to positively influence behaviour (Srigley et al. 2015). It is thus key to address how can the increasingly resistant pathogens be fought and how can people prevent and control their spread. Towards this direction, the need to explore the importance of behaviour and theory and the development of dedicated evidence-based interventional approaches will be discussed in the following sections. The key role of the use of theory is further discussed later in the chapter (section 1.3.6) in light of the factors impacting on adherence to hygiene regulations (section 1.3.3) and the concept of health-related behaviour (section 1.3.4).

1.3 Overview of the role of theory in best practice promotion

The following sub-sections 1.3.1-1.3.6 aim to highlight the importance of the role of theory in best practice promotion including intervention development and human behaviour in IPC. These concepts will be presented in light of the need to develop and implement evidence-based approaches and offer effective solutions towards IPC. The concept of theory needs to be seen as part of a complex interwoven continuum of interrelated concepts that will be presented in the succeeding paragraphs.

1.3.1 Adherence to infection prevention and control practices

If the administration of antibiotics is the way to treat HAIs that have already affected a patient, then the development and implementation of, and adherence to dedicated hygiene regulations can be viewed as the way to prevent and control these infections (Lawson and Peate 2009). This contrasts 'taking antibiotics as a behaviour post-infection' and 'adhering to hygiene regulations as a behaviour pre-infection'. The focus of the current doctoral research in on the latter viz., how to avoid transmission of pathogens from the environment to patients and thereby prevent acquisition of HAIs.

The necessity for establishing regulations in order to improve hygiene conditions in hospitals has already been highlighted from the mid-19th century (Semmelweis 1983). However, only until the 1950s when high MRSA prevalence rates captured public attention in the United States of America's (USA) did the need to develop and implement dedicated techniques against the spread of HAIs become seen as more imperative than ever (Wise et al. 1989).

In the late 1960's epidemiologists from the USA reported that feedback of information about MRSA incidences in hospitals could alter healthcare staff's behaviour, a change that had the potential to lead to reduction of HAI rates (Raven and Haley 1980). Systematic attempts to evaluate IPC programs in USA hospitals focussed on assessing the surveillance and control activities. At the end of 1970's, the CDC's landmark project the so called 'SENIC Project' (Study on the Efficacy of Nosocomial Infection Control) (Haley et al. 1985 in Arias 2010), for example, highlighted that such programs need to include four critical components for HAIs reduction, namely surveillance, control, data collection by an infection control nurse and the active involvement of a physician. It was suggested that by employing the aforementioned components hospitals could track a reduction of HAIs rates of up to approximately 32% within a 5-year period (Haley et al. 1985). The authors attributed the success of the programme to the four components highlighting particularly the key role of the infection control nurse and the physician with an interest in IPC and epidemiologic surveillance as well as the collaboration between the two professionals (Haley et al. 1985).

1.3.2 Surveillance, prevention and control

Since the SENIC Project and other similar ones were published (e.g. Dixon 2011; Dudeck et al. 2013) and being aware of the constantly changing hospital environments and patterns of care provision as well as risks from new infections, the need to provide a more effective link between surveillance and prevention and control became more compelling than ever (HPS 2017). In line with this statement, Haley (1985) highlighted that a surveillance system governed by objectives should be adopted according to which hospitals should prioritise their HAIs problems focussing on morbidity, mortality and cost burdens. Such a surveillance system could thus be the mediator for developing control strategies aiming to reduce HAI (Haley 1985).

The evolution of infection control practices led the CDC to introduce Universal Precautions in 1988. Universal Precautions is a set of guidelines (established as Standard Precautions in 1996) aiming to reduce pathogen transmission to patients and healthcare staff (Curran 2015). These evidence-based guidelines focus on a spectrum of hygiene regulations including HH, safe injection practices and use of personal protective equipment (PPE) (e.g. aprons, gloves), respiratory hygiene and thorough cleaning of potentially contaminated equipment and/or surfaces (CDC 2011).

Systematic surveillance of HAIs shows that HAIs prevalence rates differ around the world thus explaining why various policy initiatives are being published across, and within different countries (Parliamentary Office of Science and Technology 2005). In the UK, National Health Service (NHS) staff are required to implement the Standard Infection Control Precautions (SICPs) in their everyday practice alongside the local NHS Trusts of board policies and guidelines (NHS Professional 2010). The SICPs as provided by the National Infection Prevention and Control Manual in Scotland incorporate the fundamental Universal Precautions or Standard Precautions but, also, extend beyond them by further including patient placement, safe management of linen and disposal of waste, occupational exposure management and management of blood and body fluid spillages (HPS 2015).

1.3.3 Factors for low adherence

In relation to the numerous hygiene regulations being implemented worldwide (Parliamentary Office of Science and Technology 2005), a plethora of research studies has focussed on healthcare staff's adherence rates and the factors influencing the proper implementation of these regulations (e.g. Maroldi et al. 2017; Porto and Marziale 2016; Barker et al. 2017). The vast majority of these regulations refer to environmental cleanliness and HH with the latter being widely regarded as the single most effective and one of the most important aspects of infection control activities (Mathur 2011). As proper HH practice is also the most simple inexpensive strategy for the prevention and control of HAIs (Herbert et al. 2013) international and national campaigns worldwide have been systematically promoting HH aiming at establishing and maintaining a global profile on HH's importance in healthcare and the fight against HAIs such as Clean Hands Count campaign (CDC 2016), SAVE LIVES, Clean Your Hands (Kilpatrick 2009), and Five Moments of HH (Sax et al. 2007).

Despite evidence proposing that "good" infection control programmes and strategies (that incorporate hygiene regulations) are adequate, healthcare staff still struggle to adhere (Zingg et al. 2015). However, why adherence to hygiene and especially HH regulations remains still low even after the considerable efforts made during the last decades is a crucial question that needs to be answered. WHO (2006) explains that there are many factors impacting on low adherence which can be as low as 0% and most of the times below 40% among healthcare staff. These factors are presented by the 'WHO Guidelines on HH in Health Care (Advanced Draft)' document and are clustered in three categories namely, observed risk factors (e.g. healthcare worker's status and gender, understaffing or overcrowding, working in intensive care unit), self-reported factors (e.g. lack of knowledge, insufficient time, disagreement with the recommendations, skin irritation, forgetfulness), and additional perceived barriers (e.g. lack of institutional priority, low or no institutional safety climate) (WHO 2006).

Apart from the aforementioned organisational, management, and environment related factors (Atif et al. 2013), psychological factors, also, act as barriers for non-, or poor adherence by healthcare staff. For example, Erasmus et al. (2010) highlighted the importance of personal beliefs about the effectiveness of HH and, also, noted that the absence of positive role models and the social norms established by senior doctors may negatively influence adherence. Lending further support to these findings was a focus group study by Efstathiou et al. (2011) which explored nurses' perceptions of the factors that affect their adherence to Standard Precautions. A major finding was participants' admission that they were not willing to or, not capable of, modifying their practice (i.e., concept of self-efficacy) as this was formed as part of the training received or part of a habitual process (Efstathiou et al. 2011). It is therefore necessary to unravel these psychological factors and develop appropriate plans to positively influence related behaviours (e.g. adherence to hygiene regulations) (Efstathiou et al. 2011).

1.3.4 Health-related behaviour

The concept of behaviour is of critical importance towards public health and changing health-related behaviour can be very challenging indeed (Kelly and Barker 2016). What is meant, though, by 'behaviour'? Various definitions of behaviour are found in the literature from both scientific and philosophical perspectives with scant consensus as to how to define it (Lazzeri 2014). To provide some examples, definitions of behaviour include "the total of movements made by the intact animal" (Tinbergen 1951 p.2), or "anything an organism does" (Pierce and Cheney 2004; p. 1), whereas others have described behaviour in terms of activities which an individual engages with (Watson and Brown 2011) as well as in terms of the relationship between the individual and the environment (Dretske 1988).

From a behavioural and social perspective, behaviour is seen as a physical process that takes place in the body and is controlled by the brain (Davis et al. 2015a). More specifically, behaviour refers to an individual's action in response to either internal or external events. In addition, these actions can be overt and measurable (motor or verbal) or covert and indirectly measurable (involving voluntary muscles) (Davis et al. 2015a).

1.3.5 Towards behaviour change in 'healthcare-associated infections-related practice

The persistent threat of HAIs has placed IPC-related initiatives at the foreground in an attempt to decrease iatrogenic harm and improve quality of care (Panagioti et al. 2017). At the heart of these initiatives lies the importance of behaviour change (Atkins 2016). This is a key concept which is tightly linked to the core of the UK Five Year Antimicrobial Resistance Strategy (Department of Health and Social Care 2019) targeted at improving hygiene practices, increasing adherence to evidence-based guidelines and controlling antibiotics prescription. These are all IPC-related behaviours and positively influencing them requires the design of effective interventions that will lead to their change (Atkins 2016).

Both healthcare staff and patients as well as their families and carers have important roles to play regarding the prevention and control of HAI (NICE 2016). However, as the aforementioned Department of Health and Social Care's Strategy (2013) along with other international commissions outline (Mitchell et al. 2015), the implementation and maintenance of IPC-related practices requires healthcare staff to take the lead in the fight against HAIs (Yokoe and Classen 2008).

Knowing the 'what' (i.e., having knowledge) and 'how' (i.e., having skills), however, of a particular behaviour (e.g. HH) and prompting healthcare staff to change their behaviours (e.g. to improve HH practices) through the implementation of dedicated interventions does not necessarily lead to positive outcomes (e.g. improved HH compliance, decreased HAIs rates). In other words, behaviour is not always guided by perfect logic, but is rather influenced by social, emotional and environmental factors that might lead to inconsistent practices (Dolan et al. 2010; Darnton 2008).

The importance of understanding the underlying processes and factors influencing practice is embraced by the new strategy of behavioural and social sciences in public health (PHE 2018a). Of central focus in this strategy is the concept of behaviour change. The strategy highlights the need to adopt transdisciplinary approaches towards understanding behaviour and behaviour change as well as improving people's wellbeing considering the whole individual, as well as the wider social context in which she or he lives.

1.3.6 The importance of the use of theory

The elucidation of the underlying processes and factors influencing behaviour could be facilitated by the use of theory for the development of pertinent behaviour change interventions (French et al. 2012; Moore and Evans 2017). More specifically, theory is seen as a toolbox that allows for hypothesis testing and evidence accumulation, identifying constructs that determine behaviour and offering specific techniques that should be integrated when developing interventions (Prestwich, Webb and Conner 2015). Bluethmann et al. (2017) suggested that using theory to guide the development and implementation of behaviour change interventions is believed to improve the effectiveness of interventions. Webb et al. (2010) further explain that theories of behaviour change are heterogenous in nature as they move across a continuum from explaining how individuals are motivated to change their behaviour, to how they interpret their motivation into behaviour change, to how they sustain newly adopted behaviour and eliminate the risk of potential relapses. Despite the existence of equivocal interpretations regarding the usefulness of theory (e.g. Angus et al. 2013; Prestwich et al. 2014) national (e.g. Government Social Research, UK; Darnton 2008) and international (e.g. WHO 2008) health-related organisations highlight the importance of theory by urging researchers to adopt a coherent theoretical basis for behaviour change intervention development.

The aforementioned heterogeneity of theories is reflected in the different types of theoretical approaches that exist. More specifically, a momentum of implementation science is evident reflecting the systematic promotion and integration of research evidence into routine practice (Bauer et al. 2015). This momentum which has accrued over the last decade has resulted in a mounting interest in the use of theories, models and frameworks (Nilsen 2015). Although, these three concepts are distinct to each other they are regularly used interchangeably (Rycroft-Malone and Bucknall 2010) rendering the selection of the most appropriate approach by researchers challenging (Martinez, Lewis and Weiner 2014).

Such a need to adopt evidence-based approaches reflects the importance of understanding and explaining human behaviour and how behaviour change can be achieved. Recognising the necessity to elucidate the subtle differences of the concepts of theory, model and framework, Nilsen (2015) has provided a clarifying taxonomy in an attempt to achieve a common terminology and foster cross-disciplinary communication among researchers. A brief explanation of these concepts is provided below (sections 1.3.6.1-1.3.6.3).

1.3.6.1 The concept of theory

Theory refers to a set of analytical principles or statements that aim to guide our understanding and provide explanations of what is happening around us in a structured manner (Carpiano and Daley 2006). A theory comprises definitions of variables in relation to a certain area of interest where relationships between the variables as well as predictions take place (Bunge 1967; Reynolds 1971). According to Wacker (1998) a core concept of theory is its abstraction level referring to the degree to which theory is "independent of time and space". The degree of such an independence reflects on grand or general theories which are unlimited in terms of scope (i.e., high abstraction level), theories which tap on a limited set of phenomena (i.e., middle abstraction level) and theories which provide minimal scope and application of empirical generalisation (i.e., lower abstraction level) (Wacker 1998).

1.3.6.2 The concept of model

The concept of model is tightly related to the concept of theory and their difference is not always clear. Models, however, tend to have a more limited scope of explanation when compared to theories and present a simplification of a phenomenon. Another characteristic of models is that they tend to be more descriptive in nature while theories can be both explanatory and descriptive (Frankfort-Nachmias and Nachmias 1996).

1.3.6.3 The concept of framework

Frameworks, when contrasted to theories and models, do not provide explanations of observed phenomena. They rather tend to describe and make these phenomena fit according to predefined categories (Frankfort-Nachmias and Nachmias 1996). For this reason, frameworks usually refer to a structure, system or plan of a range of descriptive aspects (e.g. concepts, variables) including their interrelationships that account for a specific phenomenon (Sabatier 2007).

1.3.6.4 Terminology used in the thesis

The term 'theory' is used in an inclusive manner throughout the current thesis to include models and frameworks. When it is necessary to refer to certain models and frameworks the precise name of these approaches will be provided. The use of behaviour change interventions in IPC has been found in a more incidental way in literature but has, to date, not been systematically examined. This was identified as a gap in the literature and formed the basis for conducting an integrative literature review. The rationale for the latter is further explained in sections 1.5 and 1.6 as well as in the related Chapter 3. The following section 1.4 presents the concept of visualisation which along with theory is believed to be important in the development of behaviour change interventions in the HAIs and IPC context.

1.4 Overview of visualisation approaches

Another key concept central to this thesis is the concept of visualisation. This section aims to present how visualisation approaches have been adopted in intervention development in healthcare and highlight their potential usefulness in IPC-related interventions. It is important to highlight that at the outset of this PhD project the concept of visualisation was approached from a general perspective to refer to any visual form that can facilitate the delivery and implementation of behavioural interventions (e.g. colourful posters, video-based interventions). This initial, general, understanding of the concept of visualisation evolved as the project was progressing, leading to the development of an operational definition of visualisation which is presented in Chapter 4 as part of the conducted integrative literature review of visualisation-centred interventions.

1.4.1 Visualisation approaches in behaviour change interventions

The use of visualisation approaches in intervention development has recently received a resurgence of interest in promoting behaviour change (Hagger et al. 2015). Moreover, visualisations are increasingly being adopted in a range of healthcare interventions including obesity (Ogden and Sidhu 2006), physical activity and eating behaviours (Michie et al. 2011), increasing and sustaining positive emotion (Sheldon and Lyubomirsky 2006), breast cancer (Harrow et al 2008), asthma and physical activity (Murray et al. 2016) as well as in non-health-related research areas as in climate change (Sheppard et al. 2011) and landscape and built environment (Laing, Davies and Scott 2005).

Williams et al. (2012) explain that visualisations in behavioural interventions refer to the use of visual media as a means of communicating their message. In their worked example Williams et al. (2012) created animations as part of a cardiac intervention that aimed to motivate individuals at high cardiovascular risk towards lifestyle changes. The authors suggested that the concreteness of the visual images offer participants an increased sensory engagement thus leading to a potential higher intervention impact. Bradley and Lang (1999) lend further support to this notion suggesting that visual images influence emotion and cognition which are two core determinants of behaviour.

Distinct benefits of visualisation approaches over other communication forms in behavioural interventions have been described. For example, visualisations are more memorable than textual, or verbal interventions (Prabu 1998). It is, also, suggested that visualisations via mental imagery can promote rumination and therefore lead to a longer-term intervention impact (Cameron 2003). In addition, the success of visualisation approaches is suggested to rest on the concept of 'visual literacy' as a means for using and comprehending visual approaches to communicate with others (Avgerinou and Ericson 1997). This concurs with DeWalt et al.'s (2004) suggestion that visualisations are less dependent on language or literacy skills.

The importance of adopting a strong theoretical basis when developing behavioural interventions is also acknowledged for the success of visual interventions (Murray et al. 2016). Along with the importance of a sound theoretical basis, Williams et al. (2012) proposed the use of a narrative structure around which the visualisation intervention conveys its message and a clear consideration of how the intervention content is communicated (i.e., form and medium).

1.4.2 Visualisation approaches in infection prevention and control practice

Pathogens, a key concept in HAIs and IPC, are under normal circumstances invisible to the naked eye. To address this challenge, the need to employ innovative approaches and visual material in healthcare practice has been highlighted (West et al. 2006). In line with this and recognising the complexities of the behaviours involved in IPC practice, Prieto (2016) underscored the need to adopt interdisciplinary approaches towards novel directions. Further supporting the aforementioned statements is a systematic review by Huis et al. (2012) in which the authors highlight the need to develop interventions by applying more creative and alternative components in order to improve hygiene compliance.

Echoing the above needs, Macduff et al. (2014) sought to explore the concept of pathogens' visualisation and how healthcare staff and patient representatives visualise them in the HAIs context. By implementing an arts-based methodological approach, Macduff and colleagues were interested in how participants envisage pathogens, how they mentally represent them as well as how they engage with 'making and modelling' activities when asked to create 3D pathogens' representations (Macduff et al. 2014). Importantly, it was suggested that images of pathogens do exist in a liminal stage in people's minds and come into play in a substantive way when asked to engage with this concept (visualisation of pathogens) in a more conscious way (e.g. when asked to visualise HH practices in the HAIs context) (Macduff et al. 2014).

The above observation coupled with growing evidence suggesting that visual images may play a very substantive role in guiding responses in healthcare because they are more memorable and evocative than verbal messages (Williams and Cameron 2009), provided a strong case for implementing visualisation-based interventions in the HAIs field. However, this area as in the case of the use of theory, is very under-researched and this thesis addresses these knowledge gaps. To address these gaps a second integrative literature review targeted at the concept of visualisation was conducted (Chapter 4). The following sections provide further explanations as to its underpinning rationale and the development of the thesis structure.

1.5 Initial research plan

Drawing substantively on the aims and objectives of this PhD's studentship (as advertised in early 2015), the research proposal outlined in early 2016 as part of the formal PhD student registration process aimed at designing, developing and pilot-testing a theory-, and visualisation-based intervention. However, the author's initial scoping work to determine a rationale for theory and visualisation approaches raised more questions than answers.

At the early stages of the study, it was thought that the primary literature evidence would suffice to support the researcher's propositions. However, subsequent scoping of the literature that explicitly combined all three concepts (namely HAIs, theory and visualisations) raised the question of whether it would be worth undertaking one single integrative literature review with so few potential studies (*n*=4) (i.e., Sharma et al. 2015; Hargrove 2014; King et al. 2016; D' Egidio et al. 2014). Also, its potential futility was corroborated by Cochrane systematic reviews reporting two and four included studies respectively (e.g. Gould et al. 2007; Gould et al. 2010). A more expansive review of each concept in combination with HAIs i.e. theory and HAIs and visualisation and HAIs would, thus, be more enlightening and likely to lead to further developments in the field, considering that no reviews exist in either of these domains. As such, conducting two separate literature reviews would firstly establish the state of the art within and across each field, and then serve as a basis for further developments. The design of the doctoral research evolved as further insights were gained upon completion of the two integrative literature reviews (Phase 1) and consideration of their findings.

1.6 Aims and objectives

The current research is, therefore, aiming to explore the following overarching research question of:

> *How can theory and visualisation inform behaviour change interventions designed to help healthcare staff prevent and control HAIs?*

The above question will be answered in light of the need to design interventions using theory, as theory-based interventions appear to be more effective and the potential of visualisations as a powerful concept for behaviour change interventions. A clear justification of the theoretical basis of the intervention facilitates investigators to identify and better understand the causal pathways of HAIs-related behaviour change occurrence among healthcare staff. Equally, considering the dynamic and interactive nature of visualisations, a clear justification of their type and context offers the potential to strengthen the intervention thus impacting on healthcare staff's HAIs-related behaviours.

Little is known about how the two concepts can be optimally combined, and what the relative importance and usefulness of visualisations are among healthcare staff in relation to their HAIs-related behaviours. The current research thus aims to move beyond existing research evidence and contribute to the limited evidence base for the field of HAIs.

Considering the dearth of detail and justification about the developmental process and content of existing HAIs-related interventions, and the overarching aim of this research, this research programme evolved as a sequential multi-method inquiry to address the following research questions:

- *What is the nature of, and wider context within which theory-based and visualisation-centred interventions have been implemented?* – These questions have been explored through two separate integrative literature reviews (IR) – Phase 1

- *What are key experts' opinions on issues related to theory and visualisation in the context of behavioural interventions and how can the related guidance be harnessed?* – These questions have been explored through the conduct of a Delphi study– Phase 2
- *What are the opinions, perspectives and experiences of healthcare staff around HAIs and interventions using theory and visualisation as well as developing more effective interventions?* – These questions were explored through focus group discussions – Phase 3

In Phase 1, knowledge gaps were identified that reflected the need to do more initial groundwork than anticipated at the very beginning in relation to logically linking the two IRs in a way that could underpin the design and test of an intervention. Phases 2 and 3 built upon the gaps identified in the IRs and facilitated the development of recommendations within an inclusive approach involving key stakeholders (i.e., academics, researchers, nurses). The gaps identified in the two IRs are presented and discussed in the relevant Chapters 3 and 4.

Figure 1.3 represents the selected methods employed and shows how they connect to each other. This schematic representation will form the basis for a more detailed presentation of the methods as well as the overarching methodology of the thesis that is presented in Chapter 2.

The recommendations that the current research aims to develop are geared primarily towards researchers and practice developers, and are anticipated to increase the chances that they use an optimal combination of theory and visualisation for the development of HAIs-related interventions. There will be thorough consideration of issues such as the long-term effectiveness of the intervention, factors influencing healthcare staff's HAIs-related behaviours and their opinions and views on such interventions. It is therefore envisaged that this research will serve as a catalyst for the development of behaviour change interventions utilising theory and visualisations primarily in the HAIs field, but will also offer useful guidance for intervention development in other aspects of healthcare.

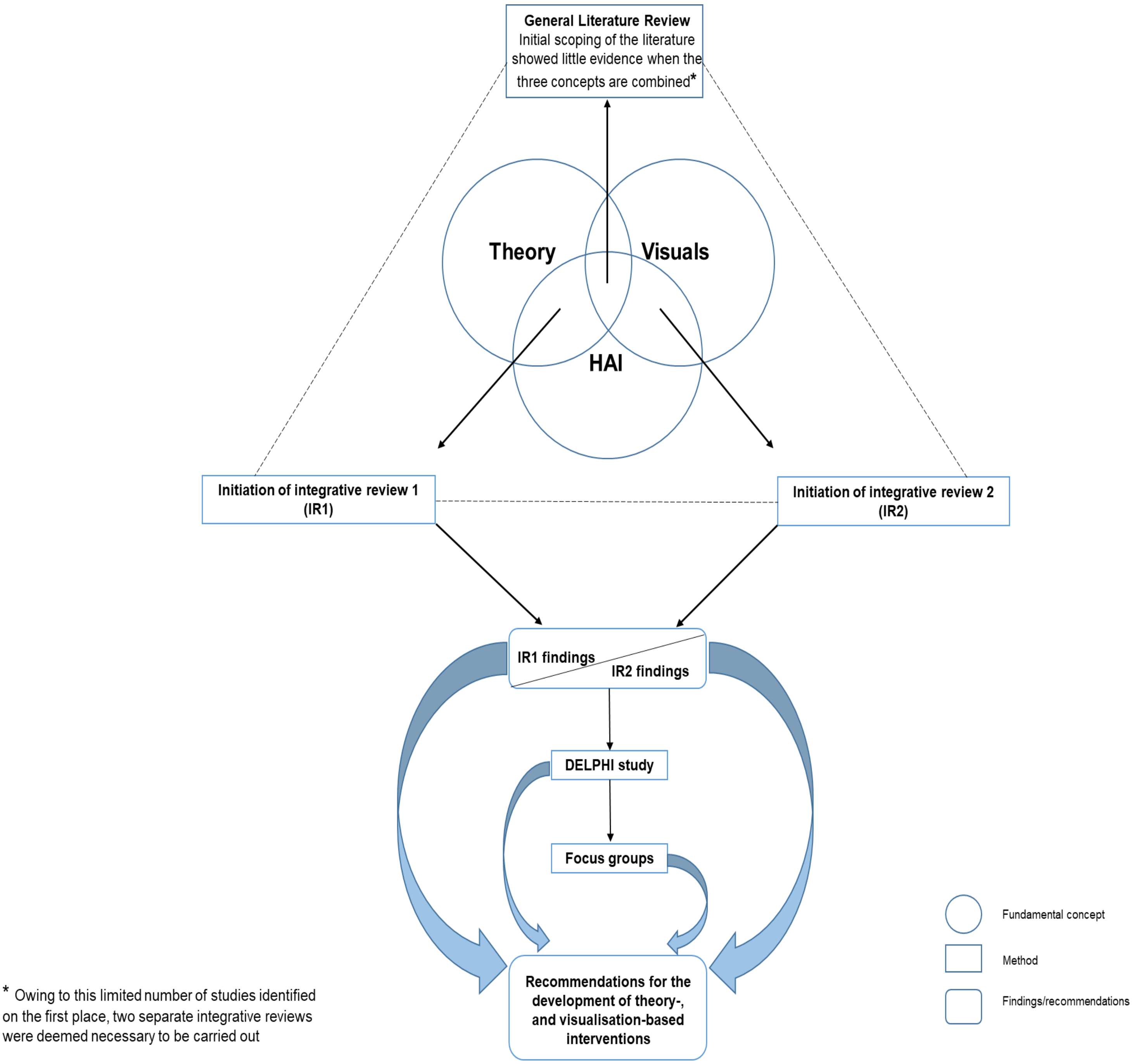

Figure 1.3. Schematic figure showing the selected various methods and their connections

Chapter 2

Design and Methodology

CHAPTER 2

DESIGN AND METHODOLOGY

2.1 Introduction to the Chapter

The study employs a sequential multi-methods pragmatic inquiry approach. In this chapter the methodological choices which have underpinned the thesis approach will be presented. A number of core concepts will be discussed including the philosophical paradigms, the overarching design and methodology of the thesis, the specific methods used in each phase, the ethical considerations as well as the role of the researcher in the conceptualisation and development of the thesis. The finer details of the selected methods including sampling and procedures involved will follow within each relevant subsequent Chapter.

2.2 Objectives of the study Phases

This subsection presents the objectives of the three Phases of the thesis and explains how one Phase links to the next. This will allow to better comprehend the 'sequential' character of this research as it will be discussed later in the chapter.

It is, also, important to reiterate that the current research aims to explore the field of IPC and HAIs in depth with a view to developing evidence-based recommendations for designing behaviour change interventions combining theory and visualisation. Towards this direction the overarching research question that guided this research is:

> *"how can theory and visualisation best inform behaviour change interventions designed to help healthcare staff prevent and control HAI?"*

The identification of knowledge gaps as part of the general literature review regarding the combination of theory and visualisation approaches for the development of behaviour change interventions in the fields of HAIs and IPC dictated the further and in-depth exploration of these concepts by conducting two separate integrative literature reviews (IR). The two IRs formed Phase 1 of the current thesis.

2.2.1 Research questions of Phase 1

It must be highlighted that the two IRs were initially conceptualised with the overarching thesis aim to develop and implement a pertinent intervention among healthcare staff. With this aim in mind, the general literature review provided insights as to what research questions should be addressed. Although more questions could have potentially been posed, it was decided that three would benefit the most the conduct of the two IRs. More specifically, the two integrative literature reviews aimed to address the following questions referring to behaviours in IPC:

- What theory-based (IR1) and visualisation-centred (IR2) interventions have been implemented?
- How are these interventions structured and applied?
- To what extent are these interventions effective?

Towards this aim, it was envisaged that the two IRs would provide clear and definitive indications of what types of theories and visualisations as well as how can best be combined within behaviour change interventions thus allowing the development and implementation of such an intervention. However, the lack of strong indications along with the identification of additional knowledge gaps following the analysis of the two IRs resulted in reconsidering the initial plan. This included a period during which the researcher developed and considered alternative research plans that could follow the two IRs.

Overall, and as it is discussed in Chapters 3 and 4, the two IRs: did not determine one definitive theory (IR1) or visualisation (IR2) as being dominant in terms of frequency of use; provided low or no justification for the selection of theory and visualisation (in IR1 and IR2 respectively); identified a variety of designs the majority of which were not of strong quality in conventional terms (e.g. before and after designs); and showed no long term effectiveness in the developed interventions.

Even if the two IRs were inconclusive as to which specific types of theory and visualisation could inform the design of an intervention, they provided a first definitive mapping of the key literature on interventions in these areas (i.e., they described their nature and scope). Consequently, this provided a basis for further considerations especially as relevant research evidence in other fields (e.g. research in obesity, physical activity and asthma) is growing and suggests their potential usefulness (Murray et al. 2016; Williams et al. 2012).

The absence of a dominant theory and visualisation along with the aforementioned observations contributed to the decision not to design and develop an intervention within an experimental-based study design. Instead it was decided to explore in more depth the diverse types of theories and visualisations with regards to which of them have the potential to inform the development of interventions and how the two can best be combined and thus contribute to the development of pertinent recommendations. The two IRs are the first data collection methods used in the current research and their findings and subsequent observations inform directly the next two methods: a Delphi study with key experts (involving academics, researchers, clinical experts) and focus group discussions with healthcare staff.

Both the general literature review (Chapter 1) and the two IRs (Chapters 3 and 4) allowed research questions to be set for each of the research subsequent planned phases. The remaining 2 Phases should be seen as an interlinked chain of questions where Phase 2 (Delphi study; Chapter 5) has contributed towards the planning and conducting of phase 3 (focus group study; Chapter 6). More specifically, the thesis evolved from and through the initial general literature review as a sequential multi-method pragmatic inquiry whereby the process and findings of the two IRs generated a further set of questions that were best addressed through a Delphi study. The same rationale towards the end of the Delphi study underpinned the conceptualisation and conduct of the focus groups study.

2.2.2 Research questions of Phase 2

The decision to conduct a Delphi study emerged from the identification of additional knowledge gaps and questions linked to the two IRs that are generally not found in the papers. This Delphi study thus aimed to ask these questions to key experts and achieve consensus guidance to facilitate the development of behaviour change interventions in the field of HAIs combining theory and visualisation. This was achieved through the experts addressing the following questions:

- What types of theory and visualisation can optimally be combined to best inform the development of pertinent interventions in the field of HAIs and IPC?
- What behaviour change techniques can best facilitate the delivery of such interventions?
- How can the long-term effectiveness of such interventions be sustained?
- What statements stemming from the answers to the above questions are highly recommended by the experts (i.e., achievement of consensus)?

The above questions were considered as being more technical thus requiring specific expertise to answer them. Therefore, the sample of key experts was identified based on specific inclusion criteria in order to allow for meaningful answers and insights to be gathered. A detailed explanation of how these questions were developed and the details of the sample are presented in Chapter 5.

2.2.3 Research questions of Phase 3

The aim of the focus group study in Phase 3 was twofold. Firstly, it aimed to gather the opinions, perspectives and recommendations of focus group participants based on their everyday clinical practice in relation to IPC and HAIs. Secondly, it aimed to present part of the key experts' recommendations (Phase 2) to focus group participants, seek for their opinions and gather further suggestions on how pertinent interventions can be developed and improved. More specifically, the focus group discussions with healthcare staff aimed to answer the following research questions:

- What are the opinions and perspectives of nurses and infection control staff in relation to HAI and IPC, factors that facilitate or hinder their adherence as well as theory and visualisation approaches?

- What are the opinions and perspectives of nurses and infection control staff in relation to the experts' recommendations (from Phase 2) and finding out whether these recommendations can facilitate healthcare staff's everyday practice?
- How can the findings from the focus group discussion be harnessed in order to develop recommendations for IPC-related behaviour change interventions?

The focus group participants were seen as the future recipients of the intended theory-based and visualisation-centred interventions and therefore their contribution was believed to enhance the value of the final recommendations.

2.3 Philosophical paradigms

The concept of philosophical paradigm, also referred to as worldview, pertains to "a basic set of beliefs that guides action" (Guba 1990 p.17). Further, philosophical paradigms provide the underpinning basis to research approaches. Each philosophical paradigm describes distinctive assumptions related to ontology (regarding the nature of reality), epistemology (regarding the nature of knowledge and the justification for knowledge claims), axiology (regarding the role of the researcher and his/her values in research) and methodology (regarding the research processes) (Lincoln and Guba 1985; Creswell 2014).

Despite there being various philosophical paradigms underpinning research, four appear to be prominent in academic discourse including: post-positivism, constructivism, transformative, and pragmatism (Creswell and Plano Clark 2011; Creswell 2013a; Creswell 2014). This section initially describes pragmatism, the philosophical paradigm adopted in the thesis, and reflects on other paradigms that are commonly used to underpin research in social sciences.

2.3.1 Pragmatism: the philosophical paradigm of the current research

This research has been underpinned by the philosophical paradigm of pragmatism which seeks to elucidate whether the research has helped "to find out what [the researcher] want[s] to know'' (Hanson 2008 p. 109). Pragmatism was adopted as a guide to develop research that best suits the current thesis's aims and objectives thus allowing a "properly integrated methodology for the social sciences'' (Morgan 2007 p. 73). The appropriateness of pragmatism for exploring and illuminating the complex triad of 'IPC, theory and visualisation' is aptly reflected by Feilzer (2010) who suggests that the philosophical paradigm of pragmatism may allow researchers "to enjoy the complexity and messiness of social life and revive a flagging sociological imagination." (Yvonne Feilzer 2010 p. 14)

Pragmatism was constructed as an alternative worldview in an attempt to reconcile the proponents of post-positivism and constructivism within the wider paradigm "wars" (Gage 1989) context (Creswell 2014). In other words, the incompatibility thesis which posits that quantitative and qualitative research approaches cannot be merged is challenged by this paradigm. In addition, the pragmatic paradigm emphasised the need to use both deductive and inductive reasoning approaches. Pragmatism advocates the use of mixed-, and multi-methods and it can be seen as a pragmatic way to observe and comprehend human behaviour (Kivunja and Kuyini 2017). The research plurality which pragmatism denotes is reflected by Creswell (2013b) who highlighted that:

> *'in practice, the individual using this worldview will use multiple methods of data collection to best answer the research question, will employ multiple sources of data collection, will focus on the practical implications of the research and will emphasise the importance of conducting research that best addresses the research problem.'* (Creswell 2013b p. 28-29).

Furthermore, and considering the primary question of the thesis, the selected methods create a triangulated approach to achieve comprehensive coverage of the phenomenon (note that the concept of triangulation is explained later in the Chapter).

A short description of other commonly used philosophical worldviews is provided below in an attempt to better illustrate the distinct nature of pragmatism thus highlighting its appropriateness for the current thesis. Table 2.1 summarises the characteristics of the philosophical paradigms in relation to the philosophical assumptions.

2.3.2 Post-positivism

Post-positivism is characterised by a reductionist, logical, empirical and 'cause-and-effect' orientation. It is a philosophical paradigm that adopts a deterministic approach based on *a priori* theories and is underpinned by a scientific belief system (Creswell 2017). The paradigm involves primarily a quantitative research methodology. Observing and measuring the objective reality that exists in the world is the foundational element for developing new knowledge (Phillips and Burbules 2000).

2.3.3 Constructivism

The constructivist paradigm underpins primarily qualitative research approaches within the wider context of social and behavioural sciences (Creswell 2014). The core endeavour of constructivism is to apprehend the subjective world of human experience (Guba and Lincoln 1989). In constructivism, phenomena regarding the social world, reality, knowledge and norms and beliefs are seen as social constructions (Alvesson and Sköldberg 2009). For this reason, constructivists focus on individuals' responses (e.g. via more open-ended questioning) and how they interpret their environment thus allowing improved understanding of the social, historical and cultural context of individuals (Creswell 2014).

2.3.4 Transformative

The transformative paradigm emphasises on social justice and aims to address the political, social and economic issues that may result in social oppression, conflict, and power structures (Kivunja and Kuyini 2017). This paradigm advocates an action agenda aiming to support marginalised individuals in the society including for example feminists and disabled groups of people. (Teddlie and Tashakkori 2009).

Table 2.1 Characteristics of philosophical paradigms in relation to philosophical assumptions (adopted from Creswell 2013a)

		Philosophical paradigms			
		Post-positivism	**Constructivism**	**Transformative**	**Pragmatism**
Philosophical assumptions	**Ontology** *(Nature of reality)*	Reality is seen in a wide perception	Relativism; Multiple realities through participants-researcher interaction	Active involvement of participants in constructing realities	Accept external reality; select explanations that best produce desired outcomes; Reality is what is useful, is practical and works; social real-life issues
	Epistemology *(How reality is known)*	Replicated findings are probably "true"; impossible to fully explain reality	Observer is dependent of that being researched	Active involvement of participants in arriving at the results	Combination of positivism and constructivism
	Axiology *(Role of values)*	Inquiry involves values, but they may be controlled	Inquiry is value bound	Cultural respect; promotion of social justice and human rights; address inequities	Values play a large role in interpreting findings; Conversation between participants and researcher about beliefs and values; goal-oriented
	Methodology *(Research process)*	Primarily quantitative	Primarily qualitative	Mixed-/multi-methods	Mixed-/multi-methods
	Advantages	Gives validity & objectivity to a research	Gives various points of view and access to aspects of reality	Inclusion of disadvantaged people in the setting of the research agenda	Findings are used in ways that result in positive changes within the value system
	Disadvantages	Lack of in-depth understanding of a context	Difficult to identify right or wrong	Underpinned by a broad theoretical umbrella resulting in different ways to interpretation	Ever-changing circumstances: what is true today may not necessarily be true tomorrow

2.4 Overarching methodology

The overarching methodology of the current thesis is best described as a *sequential multi-method pragmatic inquiry*. This is presented in depth towards the end of this section.

According to Creswell (2014), there are three overarching approaches used to guide the research design offering at the same time a distinct stance upon which research can progress (see figure 2.1). These approaches are categorised as qualitative, quantitative, and mixed-methods. The research design of the current research is best described as multi-methods, a term that is often used interchangeably with mixed-methods although distinct differences between the two exist. The current section capitalises on the multi-methods approach to research design.

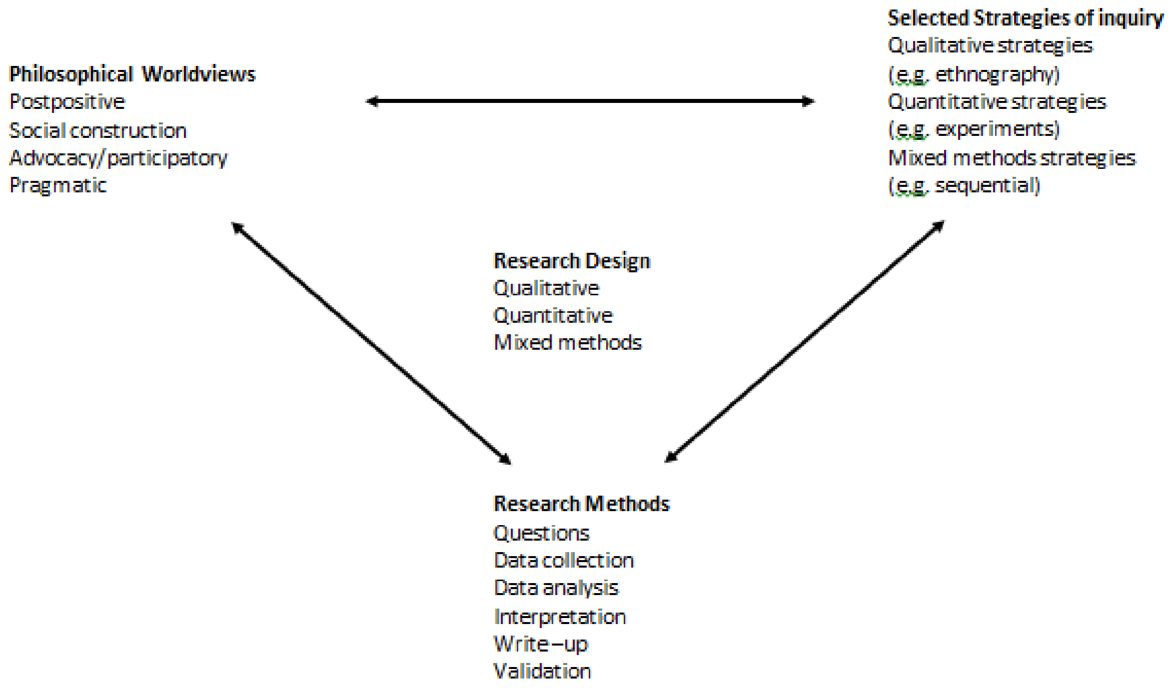

Figure 2.1 A Framework for Design—The interconnection of worldviews, strategies of inquiry, and research methods (Creswell 2014)

2.4.1 The approach to the current research design

The utilisation of various methods which are primarily qualitative in nature within a multi-methods research design was deemed as the most appropriate approach in relation to the research question and overarching aim. This approach has enabled the comprehensive exploration of how theory and visualisation approaches can best be combined when developing behaviour change interventions for the promotion of IPC-related practice among healthcare staff. The key criteria for ensuring quality of the selected methods in each phase were based on how rigorously they were conducted within the recognised parameters of each method. This is further elaborated later in the Chapter under the 'Research methods' section.

2.4.2 Multi-methods in light of mixed methods approaches

Mixed methods approaches encompass data collection and analysis methods from both qualitative and quantitative approaches within a single research study (Creswell 2003; Johnson & Onwuegbuzie 2004; Tashakkori & Teddlie 2003). This form of inquiry is also known as the 'third paradigm' (Dures et al. 2011) and its supporters advise that combining qualitative and quantitative approaches offers a more complete exploration of a phenomenon than either approach alone (Creswell and Creswell 2017; Johnson et al. 2007).

As the term 'multi-method' can easily be confused, and used interchangeably with 'mixed method' it is explained in the Handbook of Qualitative Research (Denzin and Lincoln 2011) that:

> *"Writers in mixed methods are also careful to distinguish 'multi-method studies' in which multiple types of qualitative or quantitative data are collected* (see Creswell & Plano Clark 2007) *from 'mixed methods studies' that incorporate collecting both qualitative and quantitative data."* (Denzin and Lincoln 2011 p. 273).

In other words, the distinction of the above explanation is that mixed-methods approaches utilise both quantitative and qualitative methods, whereas multi-methods approaches utilise two or more quantitative or qualitative methods. The distinct nature of multi-method design is further highlighted by Morse (2003) according to whom it refers (i.e., multi-method design) to:

> *"the conduct of two or more research methods, each conducted rigorously, and complete in itself, in one project. The results are then triangulated to form a comprehensive whole" (*in Tashakkori & Teddlie 2003 p. 190*).*

The above descriptions of approaches to research designs are illustrated in figure 2.3. More specifically, according to Saunders, Lewis and Thornhill (2016) multi-methods and mixed-methods are considered as branches of multiple methods. The multi-method qualitative study component of figure 2.2 is where the current study can best be located within this methodological choice tree.

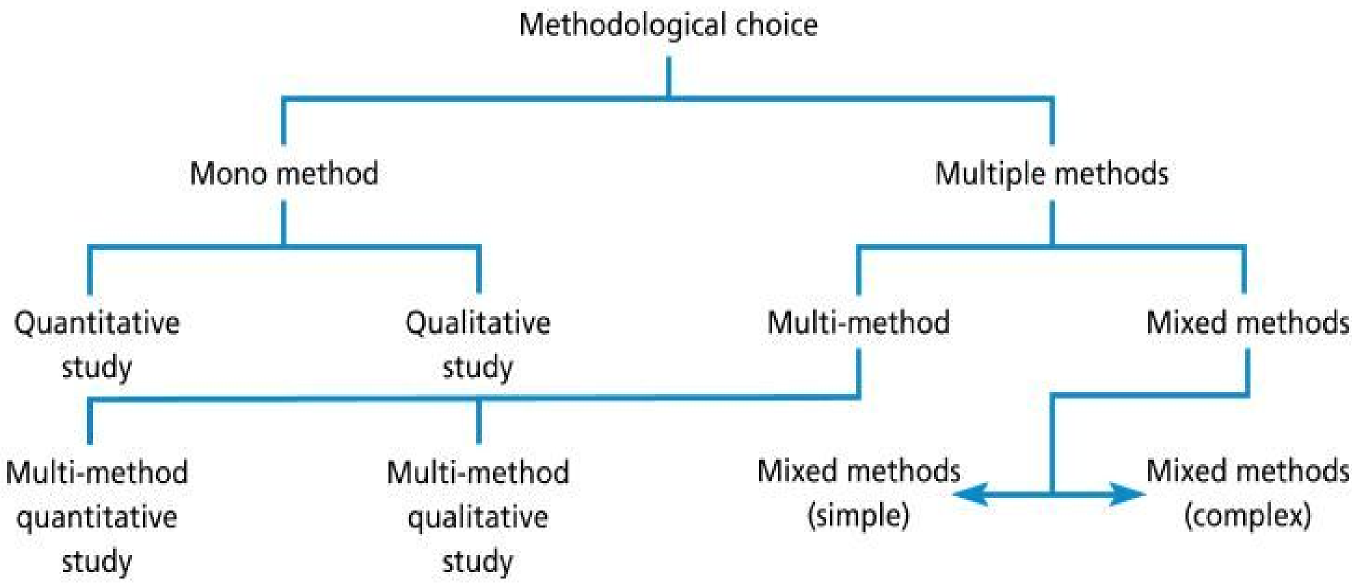

Figure 2.2. Methodological choice in relation to approaches to research (adopted by Saunders, Lewis and Thornhill 2016 p. 167)

As mentioned previously, the complexity of the research topic indicated the need to employ an array of methods. These methods are primarily qualitative in nature although two of them have distinct quantitative aspects (i.e., the two IR and the Delphi study). Nevertheless, to be more precise with the use of terminology the term multi-method was deemed as most appropriate for this research compared to mixed-methods which necessitates the conduct of purely qualitative and quantitative studies.

Within the ambit of multi-method design, Morse (2003) described two main types namely 'simultaneous' and 'sequential' providing further combinations and their characteristics within these two types. As it can be seen in table 2.2 below, the design of the current thesis maps most closely to sequential where an initial qualitative-driven project is followed by a second qualitative project (i.e., QUAL→qual).

Table 2.2 Characteristics of multi-method designs (Morse 2003)

Design type	Combination
Simultaneous	QUAL+qual indicates a qualitatively-driven, qualitative simultaneous design. QUAN+quan indicates a quantitatively-driven, quantitative simultaneous design. QUAL+quan indicates a qualitatively-driven, qualitative and quantitative simultaneous design. QUAN+qual indicates a quantitatively-driven, quantitative and qualitative simultaneous design.
Sequential	QUAL→qual indicates a qualitative-driven project followed by a second qualitative project. QUAN→quan indicates a quantitative-driven project followed by a second quantitative project. QUAL→quan indicates a qualitative-driven project followed by a second quantitative project. QUAN→qual indicates a quantitative –driven project followed by a second qualitative project.

However, the present study essentially incorporates more than two projects. More specifically, the two IR (Phase 1) have both qualitative and quantitative aspects in the logic that is driving them. Any type of literature review that is setting out to be comprehensive has an inherently quantitative aspect in that it is trying to sample the total population of relevant studies around a particular area of study (Grant and Booth 2009). This suggests that quantitative approaches reflect a deductive reasoning ('top-down') that moves across a continuum from making observations and collecting numerical data to examining the potential associations between the key variables involved and establishing a theory (i.e., moving from the general to the specific) (Williams 2007). Despite the presence of quantitative aspects, the two IRs in this research are mostly qualitative in terms of the underpinning process where assessment is taking place against certain criteria, interpretation and reflection by the researcher.

Similarly, the Delphi study (Phase 2) whose direction is informed by Phase 1 is comprised of three rounds. Overall, the study aspires to sample the total relevant population of key experts through a questionnaire and survey thus attributing qualitative and quantitative aspects. Round 1 is purely qualitative as it is solely a questionnaire-based round including open ended questions. Rounds 2 and 3 are also predominantly qualitative with quantitative aspects where 'tick box' responses were totalled up to summarise (in the form of descriptive statistics) across the sample of participating key experts. Additionally, participants were asked to qualitatively provide their reasoning for their responses.

Finally, Phase 2 guided the focus group study (Phase 3) with selected findings from the Delphi study being presented to the focus group participants. This Phase was purely qualitative as it aimed to gather participants' views and experiences around IPC and HAIs in relation to their everyday clinical practice.

2.4.3 Triangulation in multiple methods designs

The concept of triangulation is paramount in multi-methods research and is regarded as the application of multiple approaches so that various viewpoints or perspectives can illuminate a topic (Olsen 2004). Triangulation was initially adopted in qualitative research in the 1950s as a technique to avoid biases stemming from using a single methodology (Williamson 2005).

Triangulation, no matter what form it takes, has widely become a staple in social science research (Wilson 2014). Combining various methods is thought to be the most common type of triangulation (i.e., methodological triangulation) although three more types have been regularly used and outlined namely, data triangulation, investigator triangulation and theory triangulation. These types are presented in table 2.3 below. Within the multi-method research context of the current research, the use of triangulation both in terms of the use of different sources of data and various methods to gather data has enhanced the strength of the research and increased the trustworthiness of the findings (Creswell 2014).

Table 2.3 Triangulation types and their characteristics (Denzin 1978; Flick 2002; Flick 2009)

Type	**Characteristics**
Data triangulation	Use of different sources of data.
Methodological triangulation	Use of more than one method to gather data.
Investigator triangulation	Use of more than one individual in gathering data.
Theory triangulation	Approach of data with multiple theories of perspectives.

Triangulation in this study works in a very specific way and in relation to the concept of convergence. Creswell and Plano Clark (2007) explain that convergence is the merge of quantitative and qualitative data to address the study aims by combining aspects of both quantitative and qualitative research. Also, a recent report from the Massachusetts Institute of Technology (MIT) noted that convergence refers to a problem-solving approach that incorporates multi-disciplinary expertise to address certain challenges and develop solutions (MIT 2016 in Dzau and Balatbat 2018).

In the context of the current research, the studies employed in the three Phases built on each other and provide sufficient qualitative and quantitative data to allow for a coherent corroboration through description and analysis of how to best combine theory and visualisation in behavioural interventions in the IPC context. Importantly, however, divergent or inconsistent findings will also be presented in the corresponding Chapters in attempt to provide distinct differences and thus offering potentially helpful insights.

2.4.4 A sequential multi-method pragmatic inquiry

Considering that the current research sits within the philosophical paradigm of pragmatism and taking into account Morse's (2003) typology of multi-method designs the current research design can best be described as a *sequential multi-method pragmatic inquiry*.

Mafuba and Gates (2012) advocate the use of sequential multi-methods in nursing practice research as a contemporary strategy approach. Their study adopted 3 stages including a documentary analysis, an interview study and a UK-based survey. Mafuba and Gates (2012) highlighted the invaluable role of sequential multiple methods as it enabled them to adjust and refine the subsequent stages following the findings from the preceding stage. The authors concluded that this particular type of research has significant social value in that:

> *"[…] a sequential multiple-method approach to nursing research is useful and important in generating new and relevant knowledge."* (Mafuba and Gates 2012 p. 292)

Lending further support to the research design of the current research was a recent NHS report that aimed to formulate theoretically grounded, evidence-informed guidance to support best practice in effective decommissioning of NHS services (Williams el al. 2017). According to the authors the study involved a sequential multi-method research design including a literature synthesis, two Delphi studies, interviews, a national survey, case studies and focus groups all of which took place within a 3-year period. Williams et al. (2017) explained that the aforementioned methods were clustered in four interconnected ‘work packages’ which allowed for a multilevel investigation of decommissioning of policies and programmes. The authors concluded, amongst other things, that the methodological approach of the study contributed towards its original contribution to knowledge. Importantly, data triangulation between the interconnected work packages allowed for external validity and transferability of the research findings to be addressed (Williams et al. 2017).

2.5 Research methods

There is a plethora of research methods available to social scientists and which may be adopted to aid in gathering data (Creswell 2014; Creswell and Creswell 2017). The current section focusses on the methods of integrative review (Phase 1), Delphi technique (Phase 2) and focus group (Phase 3) used in this research to facilitate data collection. More specifically, an overview of these methods will be provided, explaining why they were chosen as well as outlining the main issues for conducting them in terms of quality and ethics. Again, the fine details of the selected methods including are provided within each relevant subsequent chapter.

2.5.1 Integrative reviews in Phase 1

The data collection method utilised in Phase 1 of the current research involved two integrative literature reviews (IR). The IR method was chosen among a range of similar methods such as, narrative review, systematic review and meta-analysis. Whittemore and Knafl (2005 p. 546) explain that:

> *"The integrative review method is an approach that allows for the inclusion of diverse methodologies (i.e. experimental and non-experimental research)."*

As the core focus of Phase 1 was to map and comprehensively cover uncharted territories by conducting two distinct and separate reviews, the conduct of a meta-analysis (referring to the summary of evidence by means of statistical analysis and presentation) (Glass 1976) was deemed as inappropriate. This was suggested by the preliminary scoping of the literature and was later confirmed by the completion and analysis of the two IRs. As a corollary, the two IRs in Phase 1 aimed to include a wider scope of studies than would typically be included in a systematic review as the latter often incorporates a meta-analysis component involving statistical techniques for data synthesis from various studies into a single quantitative summary effect size (Petticrew and Roberts 2008 in Uman 2011).

In order to ensure quality and enhance rigour in Phase 1, the two IRs adhered to the integrative review framework proposed by Whittemore and Knafl

(2005). The framework addresses five review stages namely, problem identification; literature search; data evaluation; data analysis and presentation and reflecting on these stages provides a more systematic and rigorous process approach (Whittemore and Knafl 2005).

More specifically, the problem identification (stage 1) was established early in the conceptualisation of the two IRs. This was based on the absence of any explicit and in-depth mapping of theory-based and visualisation-centred interventions in the field of IPC and HAIs. This consequently led to extensive literature searches (stage 2) following specific and detailed inclusion and exclusion criteria in order to capture as much a wide range of studies as possible. In data evaluation (stage 3), the final number of included studies in both IRs were evaluated in terms of the study quality utilising validated and commonly used quality appraisal tools and checklists. Quality scores for each study were independently attributed and agreed by two reviewers. This stage was followed by data analysis (stage 4) where findings were analysed primarily qualitatively employing narrative analysis. The final stage of presentation (stage 5), involved the textual presentation of study findings along with use of visual diagrams where appropriate to facilitate the studies analysis and categorisation. The presentation stage of the two IRs, also, aimed to reflect findings in the light of current research evidence, make implications for education and practice and explain how the new knowledge can be further harnessed.

The rigour of Phase 1 (and the remaining 2 Phases) was, also, enhanced by frequent meetings that the PhD researcher had with the supervisory team where the former had the opportunity to debrief the team, and receive feedback on, and scrutiny of the research project (Shenton 2004).

2.5.2 Delphi method in Phase 2

The following paragraphs aim to give an overview of consensus methods and the conducted Delphi study, outline why this technique was chosen and offer insights as to the methodological choices taken and the related justifications for them. The overarching procedure, participant inclusion criteria, demographic details as well as the detailed recruitment of the key experts are presented in the related Chapter 5.

2.5.2.1 A brief overview of consensus methods

A key characteristic of consensus methods is the concept of agreement among participants with a given issue. In this context, agreement not only refers to the extent to which participants agree with the issue under investigation but also refers to the extent to which they agree with one another (Jones and Hunter 1995). Consensus methods have been widely used in the fields of medicine and healthcare for decades now (Black et al. 1999; Waggoner et al. 2016). Also, when properly implemented, consensus methods can foster the creation of a structured environment. Within this environment participating individuals (also referred to as key experts or panellists) are provided with the best available information on a particular problem thus allowing its solution to emerge through collective agreement (Fink et al. 1984).

According to the literature, the three most common consensus methods are the Delphi method, the nominal group technique (NGT) and the consensus development conference (Søndergaard et al. 2018). The common characteristic of these methods is that they aim to systematically collect expert opinion on issues where there is abundance of, or incomplete evidence. As the gathered expert opinion is subjective, these methods do not intend to identify right answers by the respondents but instead to reflect what key experts think is important in the topic under investigation (Hasson, Keeney and McKenna 2000).

Consensus methods, despite their widespread use, have not escaped criticism owing to the absence of explicit universal guidelines as to how to conduct them. As a result of this lack of stringency in guidelines, questions may be raised about the credibility, validity and reliability of these methods. The aspects of consensus methods that pertain to such criticism are primarily the process of defining and selecting key experts and the level of consensus deemed as most appropriate (Fink et al. 1984). However, adopting a rigorous method with justified decisions and retaining a clear decision trail may be helpful in overcoming such issues (Fink et al. 1984; Powell 2003). Criticism, also, focusses on whether the achieved consensus is true, or it rather reflects an agreement that essentially conforms to the experts' average responses. This highlights that peer pressure in consensus methods may be present, but this is likely to be more prominent in consensus methods that require face-to-face participation (e.g., as in the case of NGT) (Fink et al. 1984).

Despite the criticism, consensus methods comprise useful tools that enhance decision making and aid the development of research terminology, allow for research priorities to be set, determine fundamental outcome domains and instrument sets, as well as support the reporting of guidelines (Tugwell and Knottnerus 2018). Figure 2.3 provides an outline of what consensus methods are designed to achieve across the domains of enhancing, facilitating, supporting, synthesising and determining in the wider context of the research process.

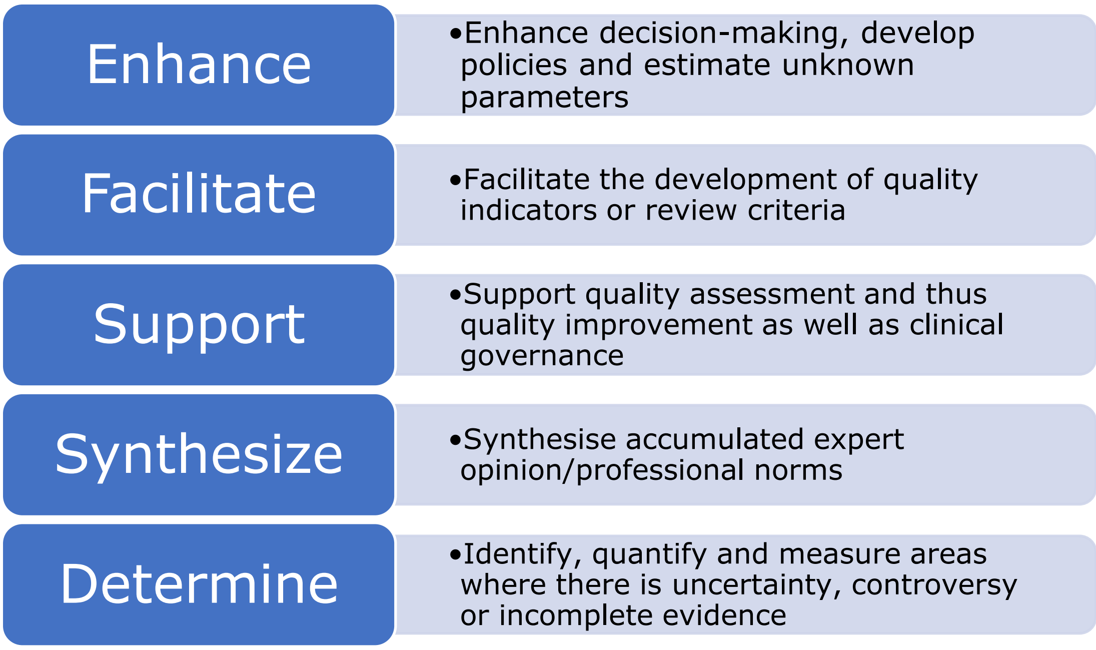

Figure 2.3 An outline of what consensus methods are designed to do (adopted from Campbell and Cantrill 2001)

The following paragraphs provide a brief presentation of the Delphi method, NGT and consensus development conference. In addition, the advantages and disadvantages of these methods are discussed in an attempt to better illustrate the appropriateness of the Delphi method that was utilised in the current study.

2.5.2.1.1 Delphi method

From a methodological perspective, the Delphi method is regarded as a combination of qualitative and quantitative methods. It was named after the Oracle at Delphi and was first conceptualised and developed by RAND (Research ANd Development) Corporation in the USA in the 1950s as a means to forecast and define military priorities and technological developments (Dalkey and Helmer 1963). Since then, the Delphi method has been widely used across a range of disciplines and research fields including nursing and healthcare (e.g. Sim et al. 2018; Bostwick and Linden 2016). Although, there are many variants of the Delphi method (e.g. modified, policy, decision, ranking-type, real time) (Strasser 2017), this section reflects on the classical form of the Delphi method conducted electronically and which was the approach used in the current doctoral research. The classical Delphi method requires panellists to respond to open-ended questions in round 1 and provide their ratings to the subsequent generated statements in the next rounds.

A key characteristic of the Delphi method is the anonymous and non-face-to-face involvement of key experts who participate in a series of iterative questioning within different rounds (Linstone and Turrof 1975). In terms of the iterative rounds and the overarching process a number of steps need to be considered. Firstly, it is important that the problem or issue under investigation is clearly defined. This will then allow for identifying and inviting suitable key experts to take part based on specific inclusion criteria. A questionnaire including usually open-ended questions is then sent to key experts who are asked to provide their opinion about the topic. These questionnaires are self-administered and are quite commonly completed electronically or by e-mail. Key experts' responses are then analysed qualitatively in an attempt to create statements that can receive rankings. These statements are included in a reformulated questionnaire which is resent to key experts. The panel is then asked to rate each of the statements indicating the level of agreement or disagreement with the statements. The ratings are then gathered, analysed quantitatively and a subsequent questionnaire is resent to key experts who can either retain their initial rating or modify it. This process can be repeated until consensus is achieved for all statements or it can be terminated earlier if a specific number of rounds was decided at the outset of the study planning (Fink et al. 1984; Jones and Hunter 1995).

The Delphi method, as utilised in the current study, offers a number of advantages based on the following attributes (Donohoe and Needham 2009; Hsu and Sandford 2007; Powell 2003; Williams and Webb 1994):

- The method is characterised by *legitimacy* and *suitability* for highly complex problems where expert opinion can contribute to, and further enhance understanding. These attributes became apparent at the very outset of the current Delphi study as the outcomes of the two IRs suggested that expert contribution would likely be beneficial. The Delphi method provides a democratic and structured approach where experts' collective wisdom is harnessed.

- Key experts' participation is *anonymous* thus reducing the effect of individuals dominating over others. The online and electronic format of the method, also, allows geographically dispersed key experts to take part as well as *confidentiality* to be facilitated. This means that *proximity* or face-to-face meeting are not a prerequisite for the study to be conducted. A Delphi study can, thus, be conducted remotely resulting in no travel costs and reducing the potential for group dynamics to emerge. The online form of the Delphi method (as utilised in the current study) renders it inexpensive.

- The Delphi method is *flexible* and *reflexive* as the researcher can adapt it to the research context and problem under investigation. In other words, the design, structure and content of the rounds can take a form that enables the gathering of rich and varied data. In addition, participating key experts are encouraged to think through scrupulously and provide honest opinions free from peer pressure.

The disadvantages of the Delphi method lie in the following aspects (Donohoe and Needham 2009; Powell 2003; Hall et al. 2018; Williams and Webb 1994):

- Despite the electronic format of the Delphi method and the use of the Internet (as in the case of the current Delphi study), Internet access challenges and technological difficulties may cause problems in the conduct of the study. In fact, such issues were identified in the conduct of the current Delphi study without however affecting its successful completion (the issues identified are discussed in sections 5.4.9 and 5.5.1, Chapter 5)

- As a characteristic of consensus methods, the criteria for selecting key experts, the panel size as well as the ideal level of consensus in the Delphi method are not based on strict universal guidelines.
- Owing to the iterative participation, key experts are required to make extensive time commitments. This may result in a decreased enthusiasm by participants from round to round or even high attrition rates.

2.5.2.1.2 Nominal group technique (NGT)

An alternative to brainstorming, the NGT is a structured variation of focus group discussions that require the face-to-face participation of key experts on a field aiming to generate prioritised solutions or recommendations on a particular problem (Sample 1984). Compared to the Delphi method which usually takes months to conclude, the NGT provides prompt outcomes for researches. The classic form of the technique includes four key stages viz., silent generation, round robin, clarification and voting (ranking) (Macmillan, King and Tully 2016).

2.5.2.1.3 Consensus development conference

The method of consensus development conference was introduced in the 1970s by the National Institute of Health in the USA where a group of people is selected to reach consensus about an issue (Fink et al. 1984). The method involves a decision-making group of approximately ten people who participate in an open meeting over the course of a few days. (Black et al. 1999; Campbell et al. 2003).

Table 2.4 summarises the key characteristics of the Delphi method, the NGT and consensus development conference method.

Table 2.4 Key **c**haracteristics of consensus-based approaches

	Delphi method	**NGT**	**Consensus development conference**
Aim	Gaining consensus among expert panel	Generating prioritised solutions or recommendations	Reaching consensus among decision-making group
Process	Use of questionnaires in iterative Rounds with feedback to experts	Face-to-face structure meetings in order to create and rank ideas	Face-to-face open meetings with experts and private discussion among decision-making group
Expert panel	Experts in the field	Experts in the field	Different disciplines
Sample size	Varies	Between five to ten participants	Around ten participants
Anonymity	Yes	No	No
Number of rounds	Varies	Two	One

2.5.2.2 The decision to use the Delphi method

The study employed the Delphi technique which was chosen in order to enable consultation from a geographically diverse group of experts and to gain consensus while allowing them to consider and respond to each other's views (Linstone and Turoff 2002; Keeney, Mckenna and Hasson 2010). The Delphi technique was, also, chosen as experts do not have to meet face-to-face thus preventing dominant individuals from controlling and guiding the group discussion. In addition, the Delphi technique facilitates anonymity among its participating experts which can allow for unashamed freedom of speech and more accurate opinion giving (Strauss and Zeigler 1975). Other relevant potential methods were considered but deemed as inappropriate included one-to-one elite interviewing (as being time consuming; Richards 1996), and the nominal group technique (as requiring participants' interaction at the same place (Gallagher et al. 1993).

More specifically, in Phase 2, qualitative and quantitative questionnaires were utilised as part of a 3-round Delphi study which was of an electronic form. More specifically, open-ended questions were asked in round 1 (qualitative Round). These questions directly reflected on the identified gaps and additional questions following the completion of the two IRs as described earlier in the Chapter. Key experts' responses from round 1 were then thematically analysed (Braun and Clarke 2006) resulting in the development of statements (thematic analysis is further presented in section 2.5.4 and in relevant Chapters 5 and 6). The key experts were subsequently asked to rate these statements in round 2 based on the degree of their agreement using a 5-point Likert scale (from 1= 'strongly disagree' to 5= 'strongly agree'). A minimum agreement consensus level of 70% was applied.

As mentioned above, the *raison d'être* for utilising the Delphi technique is to obtain consensus among a panel of perceived experts on a particular topic. However, gaining 100% agreement among experts who may differ can be very difficult (Keeney, Hasson and McKenna 2006; Keeney, Mckenna and Hasson 2010). This point was very important in the data analysis of the current Delphi study as it raised the question of what consensus percentage would denote an acceptable level of consensus. Opinions about this issue differ and there is no universally agreed consensus level as this heavily relies on the sample size, the overall aim of the study and the available resources (Hasson, Keeney and McKenna 2000). Across the literature consensus levels in Delphi studies have ranged from as low as 51% to as high as 100% (Keeney, Hasson and McKenna 2001) with their majority placed in the range between 70% and 90% (Jorm 2015). The selection of at least 70% consensus level for each statement was based on Vernon (2009) suggesting this percentage as the standard level as well as studies and research guidelines using the same threshold (Zafar et al. 2012; Kleynen et al. 2014). Only those statements not reaching the 70% consensus threshold were included in round 3. Also, for each of the statements included in round 3 participants were provided with their initial rating as well as the panel's mean rating and they were given the option to alter or retain their initial rating.

The very first step towards enhancing the quality of the current Delphi study was the continuous feedback received on the development of the study by the supervisory team. Also, before the formal initiation of the Delphi study the round 1 questionnaire was pilot-tested. Feedback on the questionnaire was provided by 6 academic experts with experience and interest in the concepts outlined in the Delphi study. The pilot-testing proved very useful as areas requiring clarification or modification were identified. Those experts who provided their feedback in the pilot-testing came from the extended academic network of the researcher and were not included in the main key experts sample for the Delphi study.

Other important issues that required further and thoughtful consideration were the number of Delphi rounds as well as the response rate between rounds. Specifically, the decision to include three rounds was based on published literature discussing the diminishing returns of including any more than three rounds (Skulmoski Hartman and Krahn 2007). The current Delphi study is better characterised as a classical Delphi study (Rowe and Wright 1999) with a qualitative first round and a combination of qualitative and quantitative subsequent ones. Other Delphi studies suggest that the number of rounds can be determined only when consensus is reached across all statements (Kim and Yeo 2018). This implies that the exact number of rounds cannot be predetermined at the outset of the study. This approach was not favoured during the conceptualisation of the study owning to the strict time constraints of the current doctoral research as well as the likelihood of increased attrition rates between Rounds.

Along with determining the number of rounds, the response rate between rounds was also of central focus in the current Delphi study. More specifically, in order to improve the credibility of the study it was intended that a minimum of 70% response rate was maintained between each round (Sumsion 1998). That was a crucial point during the conceptualisation and implementation of the study and led to taking specific actions in order to increase round-to-round participation and thus decrease participants attrition. The 75% response rate threshold was overachieved through, for example, regular contact with the participants (i.e., short and friendly reminders to provide their responses), by appreciating how busy the participants are and thus offering to them flexibility around responses deadlines as well as responding to them with individual ‘thank you’ messages whenever they participated in a round. The specific and more detailed actions taken towards increasing the response rates are presented in depth in Chapter 5.

Despite that the Delphi technique is claimed to reflect both on quantitative and qualitative methodological ideals (Simoens 2006; Bowles 1999) as is the case in the current study, it is suggested that qualitative strategies may be used to ensure trustworthiness and gauge the effectiveness and appropriates of the Delphi technique (Cornick 2006; Holloway and Wheeler 1996; Day and Bobeva 2005). More specifically, and in addition to the justification of the methodological choices as described in the previous paragraphs, strategies related to *credibility* (i.e., the truth and accuracy of findings), *dependability* (i.e., repetition of study and stability of findings over time), *confirmability* (i.e., the degree to which results can be confirmed or corroborated by other researchers) and *transferability* (i.e., the degree to which findings can be transferred to other contexts) were utilised (Anney 2014). For example, the credibility of the Delphi study was enhanced by the rounds iteration and the feedback given to key experts in relation to their responses. Based on Cornick's (2006) suggestion, the dependability in the current study was achieved by recruiting a range and representative sample of key experts (this will be presented in detail in Chapter 5).

Furthermore, confirmability was ensured by keeping an audit trail through the whole process of the Delphi study thus allowing for maintaining a detailed description of the data collection and analysis process. Finally, the decision to present part of the key experts' suggestions to focus groups participants in Phase 3 was a strategy utilised to address the transferability of the Delphi study findings. At a more general level, the trustworthiness of the study was achieved through clear explanation of the methodological decisions taken (Skulmoski, Hartman and Krahn 2007) and a clear formulation of the research questions and a detailed description of the overall procedure that was followed (Crisp et al. 1997).

Described as a pragmatic research method that aims to inform real-world practice and decision making and being widely used in social sciences (Brady 2015) the Delphi technique was chosen as the most appropriate method for Phase 2 of this research as well as for paving the way for, and inform Phase 3.

2.5.3 Focus group discussions in Phase 3

The focus group discussions involve the interviewing of a number of people (who have certain characteristics in common and relate to the topic of the interview) at the same time and relies on the interactions taking place between the group's participants. This method aims at drawing upon participants' beliefs, opinions, attitudes, experiences and feelings about the specific topic under investigation (Krueger et al. 2001). Owing to the interaction of participants within a single session thus offering the potential for rich findings along with the time constraints of both the participants (i.e., NHS healthcare staff) and the researcher the focus group method was deemed as being more appropriate compared to other similar methods such as one-to-one interviews (Ryan, Coughlan and Cronin 2009).

The implementation of the focus groups method is rooted in the person-based approach to intervention development (Yardley et al. 2015 p. 2) suggesting that:

> *"The fundamental aim of this approach is to ground the development of behaviour change interventions in a profound understanding of the perspective and psychosocial context of the people who will be using them, gained through iterative qualitative research"*

Building on the Delphi study's findings, the focus group interviews method thus enabled to delve into healthcare staff's (i.e., the future recipients of an intervention) understandings, views, and perceptions of IPC and HAIs issues. Also, part of the key experts' opinions (from Delphi study) were discussed with a focus on visualisation-centred interventions and their usefulness, what would be an acceptable visualisation-centred intervention as well as factors influencing their adherence to hygiene regulations.

Phase 3 involved in total 4 focus group discussions, 2 with nurses from paediatric services and 2 with infection control staff (who were predominantly nurses), across the two participating NHS Health Boards. Firstly, the decision to include nurses was rooted in the findings of the two IRs (Phase 1) which indicated that nursing staff were predominantly recruited within the included studies. In addition, the Delphi study suggested two intervention development options namely focal interventions (i.e., targeted to specific behaviours of individuals or teams) and systems-based interventions (i.e., targeted to whole healthcare organisations). Considering the latter finding, it was decided that the infection control focus groups would reflect the systems-based interventions (as the role of infection control teams spans across the whole healthcare institution) and the focus groups with nurses from paediatric would reflect the development of focal interventions. Although, nurses from other departments could have been recruited, paediatric services often include several departments thus allowing for a larger sample to be recruited.

With regards to how many focus groups are 'enough', it is suggested that the concept of data saturation can provide the answer. Data saturation is defined as the point at which no more or little new information is as part of data collection and analysis (Charmaz 2014). This approach, however, was not favoured for determining the number of focus group in Phase 2 as it is best intended for a grounded theory approach (Guest, Namey and Mckenna 2017). The use of data saturation was also impractical and problematic as it can only be determined during or after data analysis. Therefore, deciding how many groups and the related NHS Health Boards in advance was key especially in terms of obtaining approval from the School Ethics Review Panel (SERP) and NHS Research and Development (R&D) permission. The decision to conduct four focus group discussions, was believed to be adequate and was based on research evidence suggesting that 80% of all transcripts themes being discoverable within 2 or 3 focus group discussions, and 90% being discoverable within 3 to 6 focus groups (Guest, Namey and Mckenna. 2017). Although there is no agreement in research literature as to the focus group ideal size, the aim was to recruit 6-8 participants in each of the focus groups (Krueger et al. 2001).

With regards to the sampling procedures, it is suggested that randomisation removes the possibility of selection bias and aids in making inferences (Krueger and Casey 2014). However, this approach was not suitable as the aim of the focus group discussions was to understand and not to infer, to determine the range of participants' opinions and experiences and not to generalise and to provide insights about the participants perspectives and not to develop statements reflecting the wider healthcare populations.

2.5.3.1 The decision to use the focus group method

In-depth individual interviews with healthcare staff was also considered as an alternative data collection method for Phase 3 but the focus group method was preferred for the specific reasons explained below:

- The focus group method is a group process method which has been widely used particularly in healthcare as a powerful tool for policy analysis and development (e.g. Kahan 2001), for the development of recommendations for interventions (e.g. Holt et al. 2009) as well as for guiding the development of education curricula as in the disciplines of nursing (e.g. Vaismoradi et al. 2014) and medicine (e.g. Herrmann et al. 2007). This literature evidence along with the study's aim to inform the development of recommendations for behaviour change interventions combining theory and visualisation in the field of HAIs (see section 6.3), further corroborated the appropriateness of the focus group method.

- The focus group method allows for eliciting the participants' opinions and perspectives thus allowing the discovery of convergent and divergent aspects within and between the different focus group discussions. As it is explained later in Chapter 6 (see section 6.4.1) this characteristic of focus group was particularly beneficial in light of the two types of participants recruited and their association with the Delphi study recommendations (as per scenarios 1 and 2).
- Another characteristic inherent in the focus group method which merited its use over in-depth interviews is that the former can elicit rich information about the group's norms and opinions in a short period of time while being of low cost to conduct (Mayan 2016). In-depth interviews would have been favoured if the intent of the study was on participant's individual characteristics and especially if the subject matter was highly sensitive (Allmark et al. 2009).
- The concept of group dynamic is intrinsic to the focus group method and refers to the stimulation of conversation and reaction among participants (Farnsworth and Boon 2010). This was a key and desirable aspect as the current study aimed to explore healthcare staff's perspectives, opinions and experiences within the team they came from. The emergent synergistic interaction which takes place in the focus group method results in generating more than the sum of individual interviews (Lederman 1990; Heary and Hennessy 2006).

The key characteristics of the methods of focus group and in-depth interview are outlined in table 2.5 below.

Table 2.5 Key characteristics of the methods of focus group and in-depth interview

Focus group	In-depth interview
Elicit information about the group's norms and opinions	Elicit information about the interviewee's individual views
Group dynamic	No group dynamic
Relatively cheap and quick	Relatively expensive and time consuming
Not suitable for sensitive topics	Suitable for sensitive topics
Little personal information about respondent	Personal information about the respondent
Different perspectives	One perspective

2.5.4 Thematic analysis in Phases 2 and 3

Thematic analysis (Braun and Clarke 2006) was used as the analytical process in Phases 2 and 3. Braun and Clarke (2006) proposed two types of thematic analysis, one which is top-down or theoretical or deductive driven by the study's research questions and/or the researcher's focus. The other is a bottom-up or inductive approach that is guided by the data itself. The analysis of the Delphi study incorporated a combination of the deductive and inductive approach whereas the focus group study was more top-down rather than bottom-up.

Braun and Clarke's (2006) thematic analysis is a 6-phase analytical method that involves:

1. Familiarisation with the collected data;
2. Generating initial codes;
3. Searching for themes;
4. Reviewing themes;
5. Defining and naming themes;
6. Writing up the report

The textual responses by the Delphi and focus group participants were initially entered into an Excel spreadsheet (Braun and Clarke 2006). The first phase of analysis involved the familiarisation with the gathered data. This was achieved by reading several times the participants' textual responses and writing down initial ideas. This allowed for generating initial codes across the entire dataset (Phase 2). The code generation was facilitated by those responses that appeared interesting and meaningful to the current researcher regarding the aim of the study and the open-ended questions posed in the questionnaire. The third phase included the clustering of the developed codes into overarching themes. In the fourth phase, a thematic map was generated where the developed themes were reviewed in terms of how well they fitted with the corresponding codes. In the fifth phase, the final labelling of the identified themes was determined following further scrutiny and reading the experts' responses and generated codes. The final phase of thematic analysis involved the analysis which facilitated the writing up of the related Chapters 5 and 6. Specific examples that illustrate the analytical process are provided in the Chapters 5 and 6.

2.5.5 Ensuring the current research is ethical

A key consideration during the conceptualisation, development and conduct of all 3 Phases was that the research be not only methodologically appropriate but also ethical. At a starting point, this necessitated that all research actions were taken considering the University's related policies and ensuring that the well-being of participating individuals was safeguarded, and their rights were protected at all times. The participation of key experts in Phase 2 and healthcare staff in Phase 3 required to consider the ethical policies of the University as well as the NHS. The following paragraphs provide more details on the ethical aspects of the three Phases.

More specifically, Phase 1 did not involve the recruitment of participants and thus did not require any ethics approval to be obtained from the academic institution or elsewhere. However, principles of the Research Governance and Integrity Policy[1] of Robert Gordon University guided the conduct of Phase 1 in particular and the current PhD overall. These principles suggest that researchers should show *integrity* (i.e., honesty and responsibility regarding their own research actions), *accountability* (i.e., consideration of the ethical implications of the research) and *openness* (i.e., in terms of discussing their research with peers and disseminating research findings) and conducting research must be based on

[1] The Robert Gordon University principles:
https://www.rgu.ac.uk/files/researchgovernanceandintegritypolicypdf105kb.pdf

‘doing good’ and ‘not doing harm’ (i.e., principle of beneficence and non-maleficence). The above principles were applied from the outset of the current PhD study through its final stages via various initiatives taken by the researcher. For example, the researcher ensured that integrity was achieved through taking initiatives and ownership of the research process and by exhibiting collegiality in all scientific interactions including supervisory team meetings and departments activities (e.g. active participation in seminar talks).

The concept of accountability was reflected through directly considering and addressing the ethical implications of the research as well as the wider impact and originality of the PhD study. Considering the wider implications of the research was key as it denotes an understanding of who can benefit from the research outcomes and how the research can potentially further progress. The concept of openness was reflected through dissemination of the research outputs in national and international conferences through oral and poster presentation. The researcher’s participation at a public engagement event (‘Being Human’ by AHRC) at the start of his PhD studentship provided useful insights as to communicating his research to the public. Finally, the principle of beneficence and non-maleficence was taken into consideration in particular for Phases 2 and 3 that included the recruitment of human participants. As explained below, no risks for participants were identified as part of their participation.

In Phase 2, the Delphi study received scrutiny and ethical approval by SERP (SERP reference number: 17-23). As part of this, the ethical considerations were framed around the University’s Research Ethics Policy[2]. All ethical considerations were detailed in the student and supervisor appraisal (RESSA) form which was completed and submitted for review: Firstly, no private or confidential information was given by the participants, apart from demographic information (e.g. job role). Also, participants were communicated via e-mail and their responses to the study's questionnaire were given electronically via the in-house RGU online platform (for round 1) and a Word document-based questionnaire for rounds 2 and 3. A detailed participant information sheet was given to all participants and an informed consent form was obtained prior to the studies' commencement.

Finally, key experts’ autonomy was ensured in that they participated on a voluntary basis whilst being free to withdraw at any time without having to give

[2] The Research Ethics Policy of Robert Gordon University: www.rgu.ac.uk/research-ethics-policy

an explanation. Their consensual agreement was sought in order to publish anonymised data and non-identifiable data results. This included their dissemination as part of the researcher's PhD thesis and as conference presentations and future research publications. No harm or distress was expected to be caused to key experts as part of their participation, however participants were expected to devote some of their personal time to complete each Round. Indicative time durations for completing each round were given to participants before their participation. A detailed presentation of the ethical aspects of this part of the study are given in Chapter 5.

In Phase 3, along with SERP approval (SERP reference number: 18-15) NHS R&D permissions were necessary to be obtained prior to healthcare staff recruitment for the focus group discussions. R&D permissions were obtained from the two participating NHS Health Boards. The research governance and ethics principles as outlined by NHS Research Scotland[3] were used to inform ethical decision making in Phase 3.

In summary the ethical considerations in Phase 3 were as follow: Firstly, potential healthcare staff were identified via 'gatekeepers' across the four participating NHS sites in Scotland and distributing relevant recruitment posters. Participation was voluntary, meaning that participants could autonomously decide if they wished to take part or not. Participants were also assured that their participation was confidential including the audio-recording of the focus group discussions. The recordings were transferred to a password-protected computer and along with the consent forms and related documents they were stored securely within the University's premises. All participants were informed about the nature of the study prior to its commencement and fully consented to participate. The Data Protection Act 1998[4] and its recently revised form (i.e., Data Protection Act 2018[5]) guided the process of obtaining personal information and handling personal data in Phases 2 and 3. The fine details of the ethical implications and considerations of the study in relation to the procedures followed are fully described in Chapter 6.

[3] The research governance and ethics principles as outlined by NHS Research Scotland: http://www.nhsresearchscotland.org.uk/services
[4] The Data Protection Act 1998: http://www.legislation.gov.uk/ukpga/1998/29/contents
[5] The Data Protection Act 2018: http://www.legislation.gov.uk/ukpga/2018/12/contents/enacted

Finally, as part of the ethical considerations of this PhD research potential risks in relation to the conduct of the study and the researcher were evaluated in depth and related mitigation and contingency plans were developed. Firstly, the risk of not acquiring the data required in relation to the Delphi and focus group studies was deemed as high. Although the studies were completed within the planned timeline, it was envisaged that potential delays in communication and recruitment of the participants for the Delphi and focus group studies could hinder data collection. The mitigation plan for that risk included an initial contact of key experts (Delphi study) via e-mail explaining the purpose of the study and building rapport with them.

For the NHS focus groups, liaison with a 'gatekeeper' was established in order to inform potential participants about the purpose of the focus group and to facilitate the recruitment process. In case the above plans were not effective, alternative data collection methods would have been employed. More specifically, for the Delphi study, if the identified experts were not able to take part, they could be asked to recommend other experts who might be able to participate. If focus group discussions were not possible to be arranged, individual interviews would have taken place instead. The recruitment of healthcare staff from other NHS Health Boards was also considered as an alternative contingency option.

A second risk deemed as moderate was regarded the unforeseen slippage in the work plan (e.g. due to the researcher's potential illness). Although this risk was not the case frequent meetings with the principal supervisor and the supervisory team were taking place and prompt communication with all team members would be sought at the onset of an unforeseen slippage in the work plan.

Finally, the risk to self as researcher in relation to direct contact with the key experts and healthcare staff (i.e., in Delphi study and focus group discussions;) was considered and deemed as low (e.g. unexpected reactions by the interviewees). According to the mitigation plan the supervisory team would be made aware of the progress and stage of each study. As a contingency plan and if necessary, the researcher could approach the counselling service of the University for further advice. All communications and interactions with participants were dealt with professionalism and according to policies as described above and thus no such risk was identified.

2.6 Role of the researcher

The PhD studentship was conceived by the supervisory team as an intervention and evaluation study, however the general literature review and subsequent IRs that were undertaken by the PhD candidate at commencement called the nature and scope of existing evidence into question. The candidate's involvement in the emergent design of the study is considered as fundamental and influenced by his personal background, beliefs, interests and qualifications. More specifically, the researcher's interest and qualification in psychology and health psychology in particular resulted in embracing the concept of behaviour change and how the latter can influence IPC among healthcare staff. Behaviour change thus had a catalytic role in the research phases especially during Phases 2 and 3 which directly involved questioning individuals with a range of experience and expertise in IPC, behaviour change, theory, visualisation and intervention development.

To enhance the quality and rigorousness of the research overall, the researcher has been engaging in a range of continuous personal development activities including training workshops (organised by the Social Research Association, UK) related to conducting qualitative research and interpreting qualitative findings. Other activities included participation at seminars organised by the researcher's institution where the researcher as well as other PhD students and members of staff presented their research and disseminated their findings, and national and international conferences that allowed the researcher to deliver oral and poster presentations, converse with colleagues and exchange fruitful insights. The active participation at the aforementioned activities not only benefitted the researcher in relation to the conduct of the research, for example through constructive feedback and recommendations, but also enabled him to develop as an individual especially as an early career researcher providing motivation to fertilise ideas and proposals for potential future post-doc work. Another excellent development opportunity for the researcher involving ethical review was his participation at the SERP as a PhD student representative.

2.7 Conclusion

The current study adopted the principles of the pragmatic philosophical paradigm utilising a sequential multi-method design comprising 3 Phases. The underpinning methodological choices of the study not only ensure that each phase makes a standalone contribution to knowledge on the use of theory and visualisation in interventions aiming to positively influence IPC-related behaviours, but also when seen as a whole, offers an in-depth mapping of the field combining evidence-based approaches and rigorous methods. As a corollary, the study provides a fruitful avenue of insights and recommendations geared directly towards researchers and indirectly towards healthcare staff.

This Chapter also aimed to explain the rationale and for the selected methods and discuss the most important issues regarding the methodology and ethical implications as well as the role of the current researcher in the conceptualisation and development of this research. Apart from the specific steps and procedures, as outlined, taken to ensure a quality research, the Chapter highlights that providing the reader with a clear audit trail and thoughtful justifications are key to demonstrating rigour.

Chapter 3

Integrative Review 1

CHAPTER 3

THEORY-BASED INTERVENTIONS IN THE FIELD OF HEALTHCARE-ASSOCIATED INFECTIONS: AN INTEGRATIVE REVIEW

3.1 Introduction to the Chapter

This Chapter systematically addresses key questions concerning theory-based interventions that aim to positively influence the prevention and control of HAIs among healthcare staff through an integrative review. A narrative synthesis approach is adopted to present the findings as well as to inform and design the subsequent research phases.

3.2 Background

As seen in Chapter 1, changing behaviour is a complex phenomenon indeed and despite the establishment of behaviour change science (Parkinson, Eccles and Goodman 2014) interventions do not always apply its principles but are rather designed on the 'It Seemed Like A Good Idea At The Time' (ISLAGIATT) notion as Emeritus Professor Martin Eccles calls it (Michie, Atkins and West 2014). This means that interventions are based on the researcher's own implicit assumptions and personal beliefs (Grol et al. 2007) failing to fully comprehend the targeted behaviours, what causes them and what might be an enabler to achieving the desired behaviours (Atkins 2016). Room et al. (2017) highlight that such an absence of explicit theoretical underpinning can potentially decrease the effectiveness of behaviour change interventions.

A systematic review of studies on compliance with HH guidelines (Erasmus et al. 2010) further corroborates previous assertions about the significance of the use of theory, suggesting that theoretical models should be adopted internationally in order to elucidate the complexities of HH. Taking this suggestion further, Fuller et al. (2014) highlight that using a theoretical framework when investigating the underlying mechanisms of healthcare staff's noncompliance can provide a coherent and systematic way to inform the design of HH interventions.

In a 2012 systematic review assessing the effectiveness and sustainability of interventions to change IPC behaviour, Edwards et al. (2012) noted that only 2 out of 7 included intervention studies explicitly implemented any theory from psychology or social marketing for achieving behaviour change among healthcare staff. According to the authors, the few intervention studies identified that met both the quality and inclusion criteria (e.g. no primary care settings, focus on psychological and social marketing theories only, inclusion of countries with a developed healthcare system) denote that incorporation of theory remains at a nascent stage.

3.2.1 Problem statement

The use of theory in its broad conceptualisation when used to develop behaviour change interventions in healthcare has been linked with larger health behaviour changes compared to interventions that do not use theory (Prestwich, Webb and Conner 2015). Despite its evident importance the use of theory specifically in studies to inform IPC-related interventions has not been yet the explicit focus of in depth and systematic examination. The current integrative review was thus conducted to address this evidence gap.

3.2.2 Database search for any pre-existing review

In order to rule out the possibility that other integrative, systematic or any review type of the same nature and scope as the current one exist an initial search for pre-existing reviews was performed in the following databases: The Cochrane Database of Systematic Reviews, the Database of Abstracts of Reviews of Effects (DARE), the Centre for Reviews and Dissemination, Web of Science, AMED, CINAHL, ERIC, MEDLINE and PsycARTICLES. The search yielded no such review.

3.2.3 Review question

The overarching review question that guided this integrative review was, *'What research evidence exists around the development of theory-based interventions to aid healthcare staff prevent and control healthcare-associated infections?'*

Consequently, sub-questions to be addressed were:

1. What theory-based interventions have been implemented?
2. How are these interventions structured and applied?
3. To what extent are these interventions effective?

3.3 Methods

3.3.1 Integrative review team

The PhD candidate designed and undertook all stages of the review with support from the three members of his supervisory team who each made particular contributions at key stages as explained below. As it is recommended, a minimum of two reviewers (i.e., the PhD student and members of the supervisory teams) were involved to minimise biased decisions and error during the review phases (McDonagh et al. 2013; Centre for Reviews and Dissemination 2008). Also, valuable feedback and advice at the early stages of the process of the integrative review was sought from external advisors including a librarian and academic colleagues.

3.3.2 Study design

The current study is an integrative review of published studies. These included manuscripts published in peer-reviewed journals, as well as theses and dissertations. The integrative review methodology by Whittemore and Knafl (2005) formed the basis for conceptualising and conducting this integrative review. According to this methodology, the use of a 5-stage process can maintain rigour and decrease the bias and inaccuracy risks (Jones-Devitt et al. 2017) while enabling linkage with literature evidence of a diverse nature. The stages addressed in this methodology are: problem identification, literature search, data evaluation, data analysis, and presentation.

During the inception and preliminary stages of this review, key information about its intended design and conduct were included in a protocol registered with, and published on the PROSPERO International Prospective Register of Systematic Reviews (Centre for Reviews and Dissemination - University of York) with a registration number: CRD42016035934 (Tsattalios et al. 2016). The design of the protocol and reporting of the current integrative review was guided by PRISMA-P (Moher et al. 2015) and PRISMA (Moher et al. 2009) statements respectively.

3.3.3 Inclusion and exclusion criteria

3.3.3.1 Types of intervention

Articles were eligible for inclusion if they described an implemented intervention (or improvement programme or strategy or guidelines) making explicit and substantive use of a theory (i.e., theory underpinning the design and conduct of the reported intervention and/or analysis of results) and aiming to aid healthcare staff prevent and control healthcare-associated infections. A wide definition of theory was adopted including consideration of models and frameworks with a main focus primarily on psychological, social and human relation types theories.

No restrictions as to the content, duration and follow-up period of the reported intervention were applied. Also, there was no restriction in relation to the type of healthcare-associated infection (e.g. MRSA, Norovirus, C. difficile, etc.) in order to allow for a wider inclusion of studies.

3.3.3.2 Types of participants

Articles that addressed healthcare staff (e.g. physicians, nurses, health visitors, support workers medical educators, etc.) and/or ancillary staff (e.g. domestic staff, catering assistants, etc.) and/or academic student population from health-related disciplines (e.g. nursing, midwifery, etc.) were eligible for inclusion in the current review.

3.3.3.3 Types of outcomes

The aim to aid healthcare staff can be seen as a blend of potential outcomes moving on a continuum from raising awareness of healthcare-associated infections and hygiene practices of infection prevention and control, increasing intentions to behaviour change, increasing compliance to hygiene regulations, improving the HH technique, to decreasing infection rates and sustaining the related behaviour change.

3.3.3.4 Types of settings

Articles reporting primary, secondary, tertiary as well as 'healthcare in the community' settings were eligible for inclusion. Studies conducted in similar settings but not included in the aforementioned list were also considered for inclusion as long as they were of a healthcare-related context.

3.3.3.5 Types of studies

In terms of the study's design any article with qualitative, quantitative and mixed-methods designs were considered for inclusion. Systematic reviews, expert opinion articles, letters to the editor and conference proceedings were excluded from the review, however, whenever identified their references were screened for other eligible studies. Articles not written in English were excluded. Finally, no restrictions to the studies' quality were applied. The aforementioned inclusion and exclusion criteria used are summarised in the following table (table 3.1).

Table 3.1. Summarised inclusion and exclusion criteria for IR1 papers.

	Inclusion criteria	Exclusion criteria
Types of theory-based interventions	Focus on psychological, social and human relations theories	Theories not linked directly to human behaviour (e.g. theories from computing, mathematics, microbiology)
	Having the intention to positively influence healthcare staff	Other than having the intention to positively influence healthcare staff
	Substantive use of theory	No substantive use of theory
	Acceptance of studies with a broad conceptualisation of theory so that to include also frameworks, models and any other type of theoretical approach that guided the intervention.	
Types of participants	Any healthcare and ancillary staff as well as academic student population from health-related disciplines	Non-professional healthcare related participants being the sole participants of the study (e.g. patients only)
Types of outcomes	Outcomes moving on a continuum from raising awareness of HAIs and hygiene practices of IPC, increasing intentions to behaviour change, increasing compliance to hygiene regulations, improving the HH technique, decreasing infection rates and sustaining the related behaviour change	Any outcome out with the nature of the continuum.
Types of settings	Primary, secondary, tertiary as well as 'healthcare in the community'	Any 'non-healthcare'-related setting
Types of studies	Both experimental and non-experimental studies of qualitative, quantitative or mixed-methods nature	Reviews, Discussion papers, letters to the Editor, proceedings, published abstracts
	English language	Non-English language
	No restriction regarding the publication date of the studies. No restriction to the quality of the studies.	

3.3.4 Search strategy and database sources

The search strategy implemented in this review as well as the electronic databases used were determined through a 3-stage process which was characterised as a deep learning experience for the researcher:

1. An initial scoping exercise was undertaken prior to formally commencing this integrative review using the search terms: ["healthcare-associated infections" AND theory AND intervention] across the electronic databases

of Web of Science (formerly Web of Knowledge), TRIP, CINAHL, AMED, MEDLINE, PsycARTICLES, ERIC and American Doctoral Dissertations (the last 6 databases were accessed via EBSCOhost interface). This initial scoping exercise aimed to provide familiarity with the topic and help the researcher determine the final form and combination of the key search terms and specific databases to be searched. As part of this scoping exercise a screening grid was used

This primary stage was important for planning and conducting this integrative review, valuable insights were gathered through an iterative process within the research team and with academic colleagues who provided feedback and relevant advice. Also, during this stage, the Networked Digital Library of Theses and Dissertations (NDLTD) was screened on a later time and after the PROSPERO protocol was published.

2. In order to ensure that all potentially relevant studies were identified, the formal search strategy included a 4th key search term namely, "prevention and control". In addition, synonyms for each of the key search terms were included in the search strategy. Index terms were not used in the search process.

   The Boolean search string (i.e., using AND, OR operators) was as follows:

   1. "**healthcare-associated infection***" OR "healthcare associated infection*" OR "hospital-acquired infection*" OR "hospital acquired infection*" OR "nosocomial infection*" or "hospital infection*" OR HAI OR HAIs OR HCAI

   AND

   2. **theor*** OR "theoretical framework*" OR "theoretical model*" OR "conceptual framework*" OR "conceptual model*" OR "psychologic* theor*" OR "theory-based" OR framework*

   AND

   3. **intervention*** OR strateg* OR approach* OR "improvement program*"

AND

4. "**prevention and control**" OR prevent* OR control*

3. The formal search strategy applied the above search string (i.e., 1. AND 2. AND 3. AND 4.) across the aforementioned electronic databases excluding TRIP and NDLTD. Searches in these two databases captured more than 2,400 hits of low or even no relevance (based on their titles screening) thus rendering the abstract review impractical. As a result, it was decided to drop these two databases. Systematic reviews databases (e.g. Cochrane Library, DARE) and databases including conference proceedings (e.g. Zetoc) were not included in the formal search strategy, they were however along with policy reports and national (e.g. NHS) and international websites (e.g. WHO) accessed to provide an in-depth and contextualised understanding of the topic throughout this review.

It was decided not to apply any publication timeframe restriction to the formal search in order to allow for a more inclusive exploration of studies reporting on theory-based interventions. Finally, the databases were searched by the current researcher (KT) and the titles and abstracts of the identified results (see 3.7 Results) were independently screened by two reviewers (KT, CM) with full texts reviewed where any doubt remained. Any disagreement about whether to include a study or not was resolved through discussion. The last date for searching was September 2016.

3.3.5 Study selection

The Transparent Reporting of Systematic and Meta-Analyses (PRISMA) Flow Diagram (Moher et al. 2009) was used to depict the results for each of the 4 phases included in the search process (i.e., identification, screening of title and abstract, full-text review and eligibility, inclusion) (figure 3.1).

3.3.6 Data extraction

Data from the studies selected for final inclusion were captured using an extraction table. The extraction table was divided in columns where each article's essential information was entered as appropriate: Study details (i.e., author and year of publication), country, purpose, theory/framework, population and setting, design and intervention, duration of intervention, outcomes, findings, and author's comments and/or limitations.

3.3.7 Quality assessment

The Critical Appraisal Skills Programme (CASP 2016) various checklists were used as appropriate according to the methodological approach of each article. Whenever it was not appropriate to use one of the CASP checklists, the Quality Assessment Tool for reviewing Studies with Diverse Designs (QATSDD) was used instead (Sirriyeh et al. 2012) (Appendix 1). Also, Appendix 2 includes the CASP RCT checklist that was required to be used in IR1. The specific quality appraisal checklist or tool to be used was mutually agreed prior to the quality appraisal of the studies. Only the studies that were selected for final inclusion (n=16; see 3.7 Results section) were assessed for their quality. The doctoral student along with one of the members of the supervisory team independently assessed for their quality all the included studies (KT and CM reviewed 8 studies, KT and AS reviewed 4 studies, KT and SH reviewed 4 studies). Any disagreements were resolved by discussion.

3.3.8 Data synthesis

The synthesis of the retrieved quantitative and qualitative findings was based on Whittemore and Knafl's integrative approach (2005) implementing narrative synthesis to present study findings (Popay et al. 2006). Popay et al. (2006) developed a systematic and transparent method of data synthesis on behalf of the Economic Social Research Council Methods Programme. The narrative synthesis approach allows for studies to be summarised and findings to be synthesised on a textual basis. Narrative synthesis constitutes a framework which offers specific tools and techniques (e.g. textual description of studies, groupings and clusters) that can facilitate the synthesis of the findings). This process is importantly subjected to translation and critical reflection by the researcher (Busse et al. 2002). Considering the largely textual nature of the identified studies even during the preliminary scoping exercises conducted, the narrative synthesis approach was deemed appropriate

3.4 Results

As envisaged from the preliminary scoping exercises prior to the formal initiation of this review, the heterogeneity of the studies' outcomes, designs and settings did not allow for conducting a meta-analysis. Therefore, the studies' characteristics are presented in the following sections employing narrative synthesis (Popay et al. 2006).

3.4.1 Study selection

The combination of the 4 key search terms yielded 239 results from EBSCO Host and 146 results from Web of Science (figure 3.1).

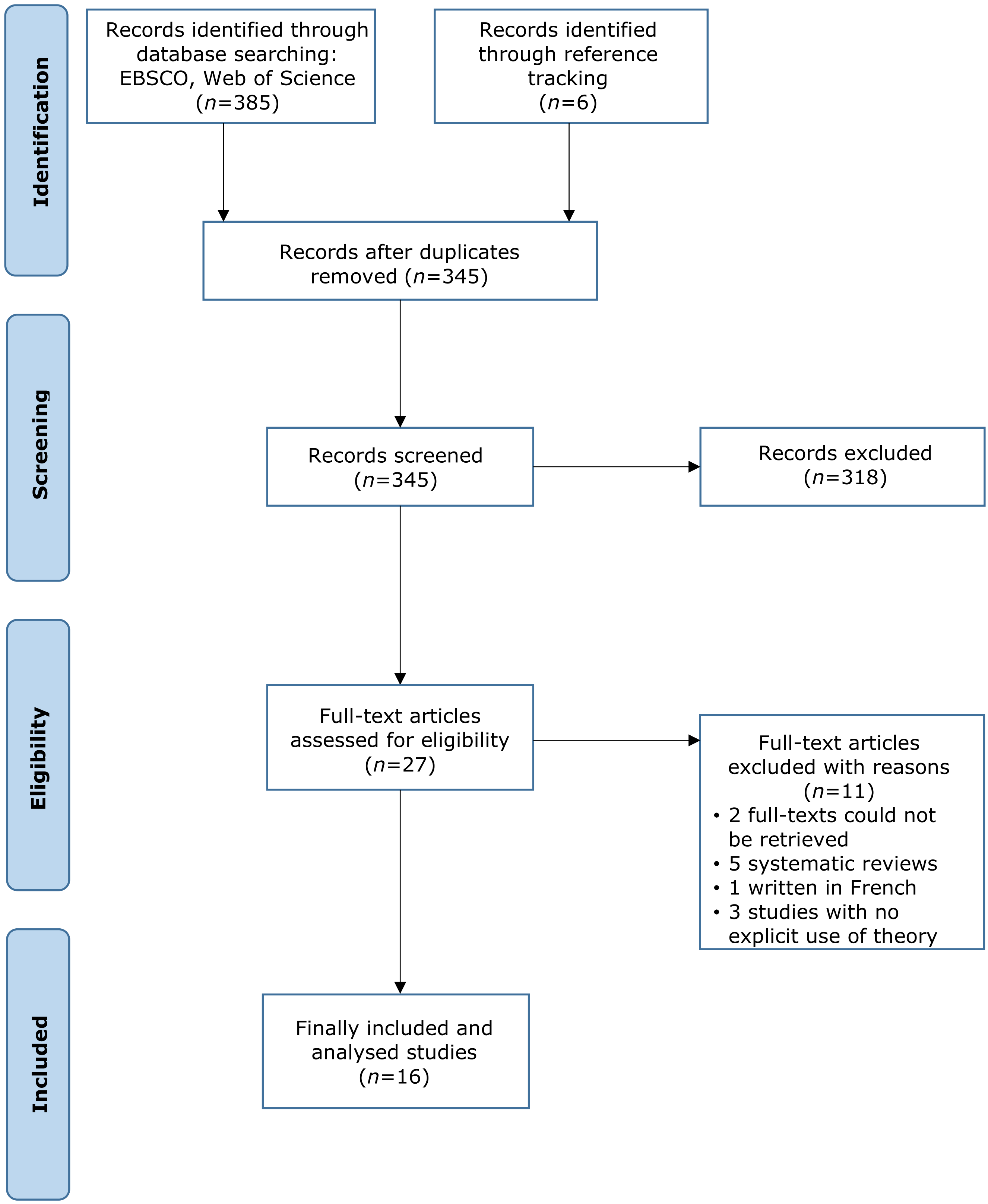

Figure 3.1. Study search process and phase results for IR1 using PRISMA Flow Diagram (Moher et al. 2009)

The retrieved titles and abstracts from all databases were entered into RefWorks software to allow for the deletion of duplications. Six additional articles were retrieved from reference lists tracking. A total of 345 titles and abstracts (after duplicates were removed) were reviewed independently by two reviewers (KT, CM) using a screening grid in order to capture each article's most important information in relation to the review's objectives. This process facilitated the final decision on whether to include the studies or not. It, also, allowed for developing distinct and meaningful clusters (see below 'classification system' for more details) for those studies that were finally excluded. It is important to note the intention was not to search for systematic reviews but ended up with 5 in the 27 full text articles assessed. These systematic reviews were not included in the final selection but were searched carefully for relevant single studies.

This screening grid included information about:

- Paper ID, authors and date of publication
- What theory has been mentioned substantively (if any)?
- Was there any intervention implemented?
- Did the study have a focus on HAIs?
- Did the study have a focus on healthcare staff?

Apart from the aforementioned important information, the screening grid also included three more columns: a section with the reviewers' decision to include the study or not, a section with the reviewer's comments and a classification section (see below for explanation). The implemented mutually agreed classification system was inspired by the principles of concept analysis (Walker and Avant 1983). For the purposes of the current review this classification system included the classification of studies (based on their abstracts) in 5 different categories viz.:

- Model cases (M) = studies where theory informs an intervention that is prospectively implemented and tested or evaluated amongst healthcare staff ('yes/no' sections in screening grid were all usually ticked as 'yes').
- Borderline 1 cases (B1) = studies where theory – purely mathematical/computer-based/biological modelling – is used

retrospectively on existing data, secondary analysis to help explain or judge.

- Borderline 2 cases (B2) = empirical studies where theory is related to the development of intervention but not an intervention that was undertaken and evaluated; mainly qualitative studies with observational or similar approaches, e.g. to understand behaviours.
- Related cases (R) = related systematic reviews, study protocols, discussion or exploratory papers primarily without explicit use of theory.
- Contrary/No cases (C) = cases of studies entirely beyond the scope of the current review that cannot be classified at any of the aforementioned categories ('yes/no' sections in screening grid were all usually ticked as 'no').

In addition to these categories, rules were discussed and agreed in order to further facilitate the studies' classification. More specifically:

- If a systematic review included theory in abstract it was provisionally classified as a Model case in order to retrieve the full text and search for other potentially relevant studies.
- If a systematic review did not include theory, then it was classified as a Related case.
- If a study protocol satisfied all criteria (i.e., 'yes/no' boxes in screening grid were all ticked as 'yes') the later full study (if it was published) was retrieved (if available).

The purpose of implementing the aforementioned screening grid and classification system was 'dictated' by the initial scoping exercise (see 3.6.3) and the identified diversity of studies in terms of their nature and scope. As such it was envisaged that the formal search would subsequently yield an abundance of results. Therefore, the classification of articles that would not necessarily be included in the review was seen as beneficial towards making wider interpretations and mappings of the field under exploration. Table 3.2 provides a detailed distribution of the identified articles and their classification before and after the full-text retrieval of Model cases.

Table 3.2 Distribution of articles' classification before and after full-text retrieval of Model cases

	M	B1	B2	R	C	Total
Before full-text retrieval	n=27	n=42	n=40	n=36	n=200	n=345
After full-text retrieval	n=16	n=42	n=44	n=39	n=204	n=345

After accessing and reading (or attempting to) the full-texts of 27 mutually classified Model cases, it was decided to include 16 studies in the review (table 3.3). The interrater agreement between the reviewers for both the preliminary and independent idenfication of Model cases and the final and independent selection of studies that were included in the review achieved strong (Cohen's kappa (κ)=.82, *p*<.001) and very strong (Cohen's kappa (κ)=.91, *p*<.001) levels of agreement, respectively (McHugh 2012).

3.4.2 Generic description of studies

The following paragraphs provide a description of the general characteristics of the included studies in relation to the study origin, methodology and methods, study population, intervention settings and study outcomes. Seventy five percent (75%) of the studies were published within the last decade with publication ranging from 2001 (Curry and Cole 2001) to 2016 (Baghaei, Sharifian and Kamran 2016; Su 2016). Those studies that were excluded after full-text screening along with reasons for exclusion are presented in Appendix 3.

3.4.2.1 Study origin

The included studies were largely based in the USA (n=7) followed by UK (n=2) and Australia (n=2) and one each in India, Iran, Ireland, Netherlands and Spain (table 3.3).

Table 3.3 Extraction table with characteristics of included studies in IR1 (table continues until page 78)

Study, country	Purpose	Theory	Population, setting	Study design, intervention	Duration	Outcome	Findings	Author's comments/limitations
Aboumatar et al. (2012) USA	To assess the effects of a program on healthcare staff HH behaviours	PRECEDE model	Hospital staff; 1,025-bed tertiary care academic center	Quantitative: time series; Multimodal intervention program: multimedia communication campaign, education, leadership engagement, environment modification, team performance measurement, feedback	14 months; data aggregation for 3 time periods of 6 months each (t0, t1, t2)	HH compliance*	74,746 observations; HH compliance increased from 34% (t0) to 72% (t2); 4.9-fold increase in odds for HH compliance over the study period	Hawthorne effect may have occurred; the study is limited by its quasi-experimental design; A significant transient increase in HH compliance occurred in April 2009, however, which was concomitant with an H1N1 influenza virus scare
Baghaei et al. (2016) Iran	To determine the effectiveness of BASNEF model on HH adherence	BASNEF model	70 haemodial. unit nurses; health and educational centers (n=2)	Quantitative: controlled quasi-experimental; BASNEF model-based questionnaire; 2 one-hour training sessions: booklet and CD including info on HH and BASNEF model	2 hours; 2-month follow-up (self-reported hand washing)	HH adherence	After intervention, subjective norms & intention increased significantly in the intervention group. No significant improvement in HH (behaviour).	Small sample size: findings cannot be generalised; data collection before-after intervention was based on self-reported HH records
Basinger (2014) USA	To reduce CLASBIs in ICUs nationwide	Rogers' Diffusion of Innovations theory	ICU staff; 49 acute care hospitals	Quantitative: before-after study design; CUSP program: monthly webinars and teleconferences	6 months; 3 follow-up sessions	CLASBI rates	Reduction of CLASBIs (32.8%) post-CUSP implementation	CLABSIs are preventable in ICUs; No intention to directly improve culture; no data collection for mortality, costs of care, length of stay
Creedon (2005) Ireland	To observe staff's compliance with HH guidelines	PRECEDE model	ICU staff; urban teaching hospital	Quantitative: quasi-experimental; observations and questionnaire (pre- and post-test), multifaceted HH programme (intervention): educational handout, poster campaign, ABHR, pre-test observation feedback by poster	6 weeks	HH compliance	73 staff observed; 32% HH compliance increase after intervention	Absence of control group and lack of follow-on observational data

Study, country	Purpose	Theory	Population, setting	Study design, intervention	Duration	Outcome	Findings	Author's comments or limitations
Curry & Cole (2001) USA	To reduce and control VRE infection rates	Ecological model of behaviour change, HBM, SCT	ICU staff; medical & surgical ICUs	Mixed-methods: QI; a multidisciplinary task force developed enhanced control measures	Implemented in April 1997 [duration unclear]	VRE rates	Decrease in VRE rates at 6 months, sustained over 2 years [no clear 'results' section]	Several behavioural models cab best explain the success of interventions [no limitations discussed]
Fuller et al. (2012) UK	To test whether a behavioural feedback intervention would produce sustained improvement in HH compliance compared to routine practice	TDF & MRC framework ; goal-setting, control & operant learning theories	Staff from 60 wards (acute care wards of the elderly and ITUs) across 16 acute hospitals	Quantitative: cluster RCT; HH observations, immediate feedback, formulation of action plans	4-week cycle	HH compliance, monthly soap & ABHR procurement data	Moderate but significant sustained improvement in HH compliance	Intervention more difficult to implement that in the exploratory trial; wards implementers neither had their training repeated nor their performance monitored; difficulty collecting secondary outcome data
Hanrahan & Lofgren (2004) USA	To evaluate the practice of placing toys in the neonatal ICU	Iowa model of EBP	Staff from a 43-bed neonatal ICU	Mixed-methods: before-after pilot; Intervention involved educating both families and staff: staff education was achieved through presenting the evidence-based findings & the impending practice change.	[unclear]	HAI rates	Decrease in HAI rates (from 4.6 to 1.99 per 1000 patient-days over a 6-month evaluation period), but not significant	Low level of retrieved evidence; multitude of other interventions concurrently re-emphasized in setting.
Harne-Britner et al. (2011) USA	To determine (i) if HH adherence can improve by educational & behavioural interventions (ii) if improvements sustained for 6 months (iii) HH adherence & HAI rates relationship	Change theory with behaviour., social science & organis. theories	RNs and patient care assistants across 3 medical-surgical units	Quantitative: quasi-experimental; control group: education in the form of self-study module with pre-, & post-test. Experimental groups: same education plus behavioural interventions: rewards for improved HH, sticker poster	6 months	HH adherence	Education alone did not sustain improved HH adherence; an environment promoting public reward may influence behavioural change more than an educational approach	Potential Unit management characteristics between groups not considered; Hawthorne effect; unit infection rates not available to share with staff

Study, country	Purpose	Theory	Population, setting	Study design, intervention	Duration	Outcome	Findings	Author's comments or limitations
Huis et al. (2013) Netherlands	To test the effectiveness of an innovative team and leaders-directed strategy in increasing HH compliance.	SLT, SIT, theory on team effectiven., leadership theory	Nurses from 67 wards of 3 hospitals	Quantitative: cluster RCT; education, reminders, feedback plus interventions based on social influence & leadership: teams and leaders-directed activities; observations re HH compliance	6 months	HH compliance, Wearing jewellery & long-sleeved clothes	10,785 opportunities for HH in 2733 nurses; sustained HH compliance in the state-of-the-art strategy. Larger HH improvement in leaders-directed strategy	HAI rates not measured; doctors not included; possible Hawthorne effect; potential cross-fertilisation between wards; H1N1 influenza during follow-up period
Lewis et al. (2014) USA	To reduce HAIs in an ADU	STS framework	[no info about healthcare staff involved]; Hospital-based ADU	Mixed-methods: QI; Intervention package: 4 components classified by HAI risk factor	6 months	HAI rates & surface contamination	No significant reduction in HAIs; bacterial surface contamination decreased	Patient lifestyle seen as ongoing challenge; no patient education addressed by intervention package; heavy workload by staff
Linam et al. (2011) USA	To improve HH compliance (>90%) using QI methods	PDSA cycle	Healthcare staff in 2 paediatric units; 475-bed tertiary children's hospital	Quantitative: quasi-experimental: QI multimodal intervention: covert observations, leadership support, improving staff knowledge, HH supply availability, staff behaviour	[intervention duration unclear]	HH compliance	HH compliance improved to >90% & was sustained for 18 months	Data collection limited to HH observations only; possible Hawthorne effect (due to presence of patient attendant in the room) led to improved compliance & may not reflect HH behaviour in other situations.
Martín-Madrazo et al. (2012) Spain	To evaluate the effectiveness of intervention in improving HH compliance	5 moments for HH	198 healthcare staff in 11 primary care healthcare centers	Quantitative: cluster RCT; multimodal improvement strategy: staff training, use of hydroalcoholic solutions, reminder posters, institutional safety environment; baseline and 6-month post intervention observations	January to December 2009	HH compliance	21.6% HH compliance improved in intervention group compared to control	Potential spill over effect; pandemic influenza A and N1H1 may have influenced the results;

Study, country	Purpose	Theory	Population, setting	Study design, intervention	Duration	Outcome	Findings	Author's comments or limitations
Pontivivo et al. (2012) Australia	Use of practice development approach to increase HH compliance and decrease HAI rates	5 moments for HH, TTM, Pathman's model	Hospital healthcare staff; 3 medical & 4 surgical wards, 1 ICU	Quantitative: before-after; multimodal intervention (coaching, competitions, group evaluation and feedback, executive endorsement)	1 year	HH compliance, HAI rates	11,247 moments for HH observed; statistically significant improvement in compliance; non-significant reduction in S. Aureus rates	It is stated that no ethical review of the project was required as it was a QI initiative; staff probably responded to covert direction; limitations not explicitly and clearly presented
Pulcini et al. (2007) UK	To decrease VAP rates	PDSA cycle	Post-graduate healthcare professionals; ICU	Quantitative: QI; education intervention: ICU charge nurse and a consultant undertook informal education concerning reasons for the change and methodology of intervention: educational meetings, audit-feedback, reminders	[timeline unclear]	VAP rates	95% protocol compliance achieved within 6 weeks for the whole unit; VAP rates unclear	PDSA cycle is seen as a useful tool, can be applied in any clinical setting leading to large changes in practice in a short period of time [no limitations discussed]
Sharma et al. (2015) India	To assess an in-house prepared ABHR & build capacity to staff	PRECEDE-PROCEED model, TTM, Social marketing, FLO	183 healthcare staff at a rural, tertiary care, teaching hospital	Quantitative: step wise study design approach (co-design); intervention: building confidence, handmade posters, reminders, supply of ABHR product	[timeline unclear]	Acceptance of ABHR product	High acceptance & demand for the product: 83% of doctors & 94% of nurses satisfied with ABHR product.	The use of fingertip culture and visual portrayal was as convincing and effective way to develop confidence in staff. No limitations discussed
Su (2016) Australia	To reduce & prevent HAIs within 6 months; to support a sustainable positive workplace culture in the surgical ward	Kotter's model	Healthcare staff in surgical ward	Mixed-methods: QI (co-design approach); HAI prevention strategies: education for all staff, HH campaign, clean environment, use of chlorhexidine bathing, active surveillance	6 months	HAI rates	35 healthcare staff completed the pre- and post-education questionnaires; significant increase in knowledge of HAIs in all types of staff; reduced incidence of HAIs;	HH compliance increased notably after the campaign; a collaborative approach is required to effectively prevent & control HAIs; limited involvement of medical practitioners

* Abbreviations are further explained in page vii

3.4.2.2 Methodology and methods

The majority of the included studies employed a quantitative methodology using observations or surveys as data collection tools (*n*=12). The remaining four included studies used mixed-method approaches including observations and use of surveys along with participants' qualitative feedback (questionnaire-based), literature reviews and qualitative data extraction from records which were utilised to inform the development of the described intervention. None of the included studies implemented a purely qualitative methodology.

The study design of the quantitative studies included time-series, quasi-experimental, before-after, cluster randomised controlled trials, and quality improvement. The study design of the mixed methods studies included before-after and quality improvement (table 3.3).

3.4.2.3 Study population

The included studies reported on using samples of nurses, patient care assistants, post-graduate healthcare professionals and healthcare staff. The exact total sample size cannot feasibly be determined due to unclear descriptions of sampling, especially in those studies using observational approaches for data collection.

3.4.2.4 Intervention settings

In terms of the study settings, the aforementioned categories of healthcare staff were recruited from a wide range of healthcare settings including tertiary care teaching hospitals (*n*=2) surgical ICUs (*n*=2), surgical wards (*n*=2), ICUs (*n*=3), nursing wards (*n*=2), a neonatal ICU, a tertiary children's hospital, a hospital-based ambulatory dialysis unit (ADU), acute-care hospitals (*n*=2), primary healthcare settings and a haemodialysis unit.

3.4.2.5 Study outcomes

With regards to the study outcomes, the reported interventions focused primarily on (i) increasing HH adherence amongst the participating healthcare staff (*n*=9 studies), followed by (ii) decreasing HAI rates (*n*=7 studies), (iii) increasing the use of ABHR (*n*=1 study), (iv) increasing the acceptability of an in-house prepared ABHR product (*n*=1 study, (v) decreasing surface contamination (*n*=1 study) and (vi) determining the presence of jewellery and long-sleeved clothes under the uniform (*n*=1). Note that the studies by Pontivivo et al. (2012), Lewis et al. (2014), Huis et al. (2013) and Fuller et al. (2012) reported on two outcomes each (Table 3.4). The specific HAIs addressed were VAP (Pulcini et al. 2007), VRE (Curry and Cole, 2001), Staphylococcus aureus healthcare-associated bacteraemia (Pontivivo et al. 2012) and CLASBI (Basinger, 2014).

3.4.2.6 Use of theories

A wide range of theories (including models and frameworks) were applied to guide the interventions reported in the included studies. In 10 of the included studies, single theories were the sole point of reference for the developed interventions (Aboumatar et al. 2012; Creedon, 2005; Baghaei, Sharifian and Kamran 2016; Basinger 2014; Hanrahan and Lofgren 2004; Lewis et al. 2014; Linam et al. 2011; Pulcini et al. 2007; Su 2016; Martin-Madrazo et al. 2012). In the remaining 6 studies, a mixture of theories underpinned the implemented interventions. A description of these theories is provided in Appendix 4.

3.4.2.7 Structure and application of interventions

The reported interventions were predominantly multicomponent (or multimodal) as they utilised multiple components to achieve the desired outcomes (table 3.3). Exception was the study by Baghaei, Sharifian and Kamran (2016) where the implemented intervention was educational based only utilising staff training on HH behaviour through a booklet and a CD.

Based on the related descriptions in each paper, approximately 60 specific and overarching components informed the reported interventions. These components are clustered in 6 wider component themes viz., education and training, monitoring and feedback, environment and resources, system and procedures, communication and support, and motivation (figure 3.2).

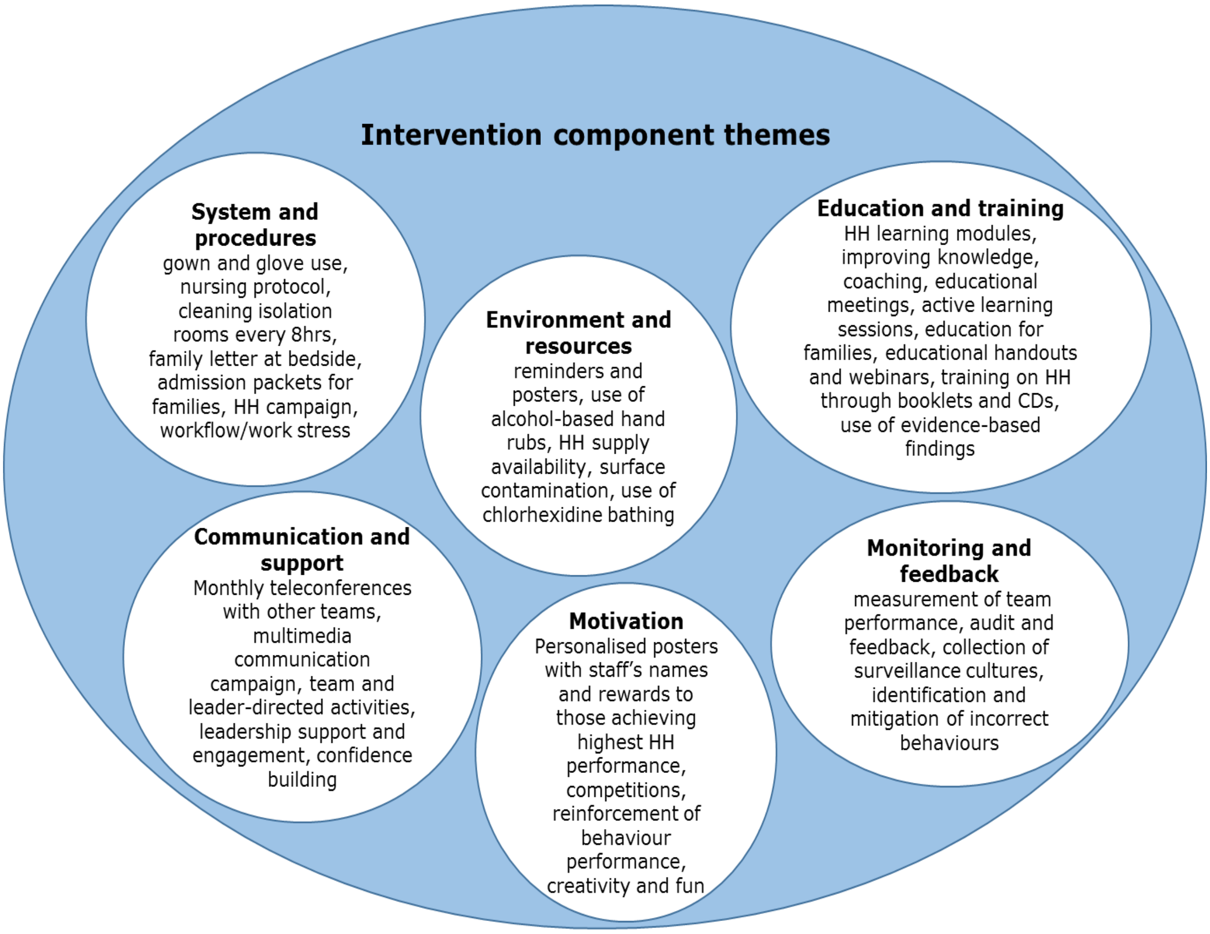

Figure 3.2. 'Intervention components' palette': overarching component themes and specific components that guided the reported interventions.

In terms of the interventions' duration including any follow-up measurements this ranged from 1-hour sessions (Baghaei, Sharifian and Kamran 2016) to 12 months or more (Aboumatar et al. 2012; Pontivivo et al. 2012). In a few cases the duration of the reported interventions and/or follow-up measurements were not feasible to be determined (e.g. Hanrahan and Logfren 2004; Linam et al. 2011) owing to lack of clear description in the corresponding papers.

3.4.2.8 Effectiveness of interventions

The extent to which the reported interventions were effective was based on the studies' reported findings and authors' conclusions. Table 3.4 shows the study outcomes of each paper and presents whether the corresponding interventions were successful at positively influencing these outcomes. The content of this table, however, should be interpreted with caution taking also into consideration the nature of the different study outcomes, the various study designs (which in conventional terms were of low quality in most cases) (see table 3.3) as well as the authors' reflections regarding the study limitations (see Discussion 3.8 below for further explanation).

Table 3.4 Success of reported theory-based interventions on primary outcomes and sustainability of effect

Study	HH compliance	Infection rates	Use of ABHR & soap	Wearing jewellery & long-sleeved clothes	Surface contamination	Acceptance of ABHR product	**Sustainability**	**Theory**
	Outcome							
Aboumatar et al. (2012)							Yes, at 20 months	PRECEDE
Baghaei et al. (2016)							N/A	BASNEF
Basinger (2014)							Yes, at 18 months	Rogers’
Creedon (2005)							Not explored	PRECEDE
Curry & Cole (2001)							Unclear	*Combination*
Fuller et al. (2012)							Not entirely achieved	*Combination*
Hanrahan & Lofgren (2004)		†					Not explored	IOWA
Harne-Britner et al. (2011)							No	*Combination*
Huis et al. (2013)							Yes, at 6 months	*Combination*
Lewis et al. (2014)		†					Unclear	STS
Linam et al. (2011)							Yes, at 18 months	PDSA
Martin-Madraazo et al. (2012)							Yes, at 6 months	5 Moments
Pontivivo et al. (2012)		†					Unclear	*Combination*
Pulcini et al. (2007)							Not explored	PDSA
Sharma et al. (2015)							N/A	*Combination*
Su (2016)		†					Not explored	Kotter’s

†Denotes success either not statistically significant or statistics not provided. **Green** colour denotes statistically significant success of the intervention in achieving the outcome, **Orange** colour denotes unclear effect of the intervention on the reported outcome and **Red** colour denotes the intervention has been unsuccessful.

With regards to the study outcomes it is essential not only to view them as part of an interwoven continuum but also as an escalation of how challenging it is to bring about change and sustain it as well as to design and sustain studies that rigorously capture more distal impacts and can make any plausible causal attributions. Figure 3.3 below depicts this perceived continuum and escalation as interpreted by the current author. Infection rates are at the top of this staircase representing the complex nature of this concept. This complexity is, also, mirrored in table 3.4 where the majority of the studies (6 out of 7) aiming at decreasing infection rates did not provide clear support for the success of the reported interventions. At the bottom of the 'outcomes staircase' is the acceptance of an ABHR product (Sharma et al. 2015) which was measured using a feedback form on a 7-point Likert scale.

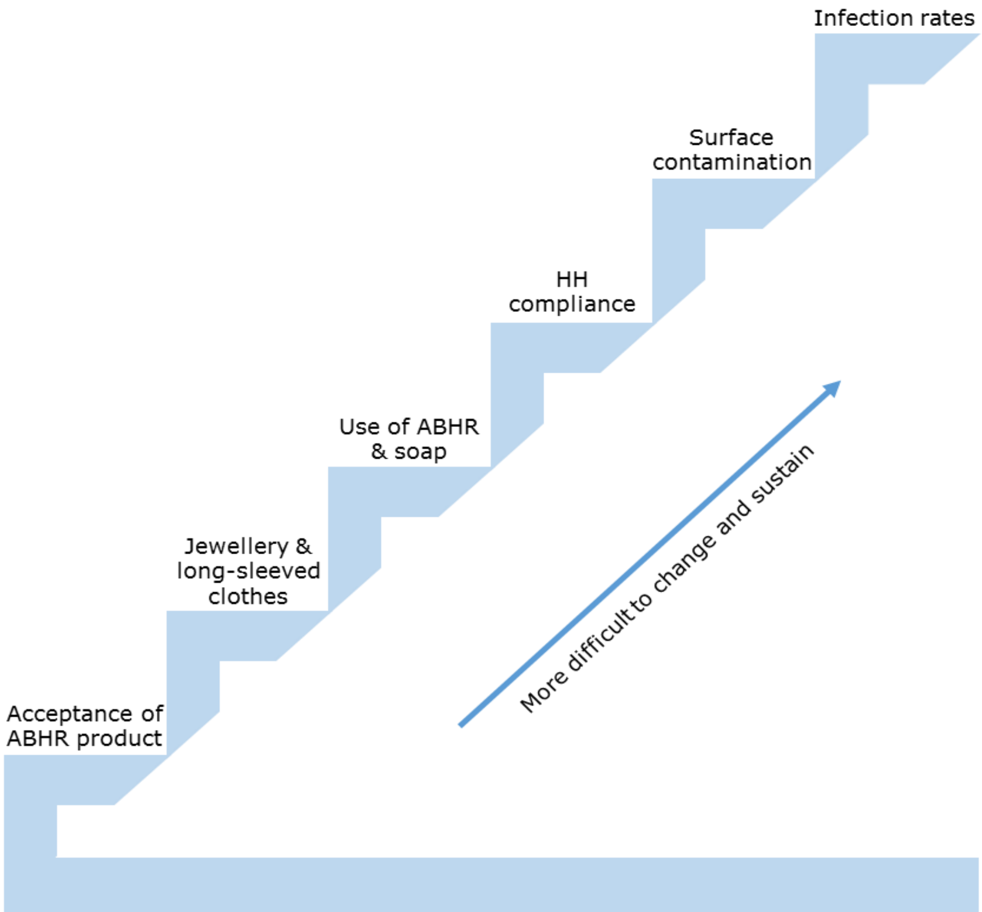

Figure 3.3 'Outcomes staircase': Intervention outcomes represented on a staircase based on their perceived difficulty to change and sustain.

3.4.3 Critical Appraisal

As can be seen in table 3.3 the included studies employed a diversity of research designs (e.g. RCT, quasi-experimental, quality improvement) falling within either quantitative or mixed-methods overarching methodologies. The CASP Checklists (CASP 2016) offer a set of 8 distinct appraisal tools (i.e., Systematic Reviews, Randomised Controlled Trials, Cohort Studies, Case Control Studies, Economic Evaluations, Diagnostic Studies, Qualitative studies and Clinical Prediction Rule) and it was decided within the research team to use them for any corresponding included study. If none of them was deemed suitable then the QATSDD tool (Sirriyeh et al. 2012) was used instead.

Of the 16 included studies, 13 were appraised for their quality using the QATSDD tool (table 3.5). Q1 to Q16 represent each of the 16 questions of the tool. The potential answers to the QATSDD's questions were either 'not at all' (i.e., 0), 'very slightly' (i.e., 1), 'moderately' (i.e., 2) or 'complete' (i.e., 3). Note, that questions 11 and 14 are marked as N/A (non-applicable) as they refer to qualitative studies only (further explanation is provided below). This led to scoring 14 questions in total with a potentially maximum score of 42. Finally, 3 studies were appraised using the CASP RCT checklist (see table 3.6).

Table 3.5 Quality appraisal of studies using the QATSDD tool (Full set of the 16 questions are presented in Appendix 1)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Total score	%	Rating
Basinger 2014	3	3	3	1	1	3	3	1	2	3	N/A	3	2	N/A	3	3	34/42	80.95	High
Harner-Britner et al. 2011	2	3	3	1	2	3	2	2	3	2	N/A	3	2	N/A	0	2	30/42	71.43	Good
Creedon et al. 2005	3	3	3	1	0	3	3	2	2	0	N/A	0	3	N/A	0	2	25/42	59.52	Good
Aboumatar et al. 2012	3	1	3	1	0	2	2	1	2	0	N/A	0	2	N/A	3	3	23/42	54.76	Good
Baghaei et al. 2016	3	3	2	2	1	2	2	1	3	0	N/A	0	0	N/A	1	1	21/42	50.00	Moderate
Hanrahan et al. 2004	3	2	3	1	1	2	2	1	0	0	N/A	0	2	N/A	0	2	19/42	45.24	Moderate
Sharma et al. 2015	2	3	3	0	1	2	1	2	0	0	N/A	0	1	N/A	1	1	17/42	40.48	Moderate
Pontivivo et al. 2012	3	2	3	0	0	2	2	2	0	0	N/A	0	1	N/A	0	1	16/42	38.10	Moderate
Linam et al. 2011	2	3	3	0	0	3	0	0	0	0	N/A	0	0	N/A	2	2	15/42	35.71	Moderate
Pulcini et al. 2007	2	3	1	0	1	1	1	1	1	0	N/A	0	0	N/A	1	1	13/42	30.95	Moderate
Lewis et al. 2014	2	2	3	0	0	1	0	1	0	0	N/A	0	0	N/A	1	2	12/42	28.57	Moderate
Su 2016	3	3	1	0	0	1	0	1	0	0	N/A	0	0	N/A	1	1	11/42	26.19	Moderate
Curry et al. 2001	3	1	1	0	0	1	0	0	0	0	N/A	0	0	N/A	1	0	7/42	16.66	Low

Table 3.6 Quality appraisal of included RCT studies using the CASP RCT checklist

	Studies		
	Martin-Madrazo et al (2012)	Fuller et al (2012)	Huis et al (2013)
CASP criteria			
A. Are the results of the trial valid?			
1. Did the trial address a clearly focused issue?	✓	✓	✓
2. Was the assignment of patients to treatments randomised?	✓	✓	✓
3. Were patients, health workers and study personnel blinded?	✓	✓	?
4. Were the groups similar at the start of the trial?	✓	?	?
5. Aside from the experimental intervention, were the groups treated equally?	✓	✓	?
6. Were all of the patients who entered the trial properly accounted for at its conclusion?	✓	✓	✓
B. What are the results?			
7. How large was the treatment effect?	?	?	✓
8. How precise was the estimate of the treatment effect?	✓	?	✓
C. Will the results help locally?			
9. Can the results be applied in your context?	✓	?	?
10. Were all clinically important outcomes considered?	✓	✓	✗
11. Are the benefits worth the harms and costs?	✓	✓	✓
Overall rating as agreed by the reviewers	High	Good	Good

✓ **means 'yes';** ? **means 'can't tell';** ✗ **means 'no'**

For those papers which used the QATSDD tool, the potential highest score that could have been attributed was 48 (16 questions in total with a highest score of 3 for each of them). However, questions 11 and 14 of the QATSDD tool were not applicable for any of the studies thus leading to 42 as the potential highest score. Each study's final score was then converted to a percentage (e.g. a score of 30/42 is converted to 71.43%). The final rating system in 'Low', 'Moderate', 'Good' and 'High' was applied according to whether each paper's score fell into the following percentage ranges (i.e., each total score was converted into a percentage):

Low: less than 25%

Moderate: 25% to less than 50%

Good: 50% to less than 75%

High: 75% to 100%

For those papers which the review team administered the CASP RCT checklist the classification system was not based on a score *per se* but it was determined on a mutually agreed decision considering the adequacy of the answered questions in the checklist. To converge with the quality ratings used in the QATSDD tool (i.e., low, moderate, good, high) the same range was used to attribute the quality of the papers appraised with the CASP RCT checklist (Table 3.6).

3.4.4 Study characteristics reflecting the research questions of the review

Following on the presentation of the generic description of the studies as well as their quality appraisal, the following section provides a thorough presentation of the studies' specific characteristics in relation to the three research questions of the current review.

3.4.4.1 What theory-based interventions have been implemented?

This section reviews the nature of theories that guided interventions in the identified studies. Although theory appeared strongly in all 16 included studies, the extent to which theory was used to guide intervention development and implementation, as well the descriptions and clarity of how theory was used varied. With regards to the former point, for example, most of the studies (*n*=10) reported on single theories as the sole underpinning basis of the intervention. Aboumatar et al. (2012) utilised only the phases of the PRECEDE construct of the PRECEDE-PROCEED model aiming to prevent HAIs. The WIPES Infection Prevention Program which they developed focused upon promoting two target behaviours namely handwashing according to guidelines and reminding other healthcare staff to perform hand washing. In order to promote these behaviours among healthcare staff from a tertiary care academic centre (8 ICUs, children's centre and oncology centre) Aboumatar et al. (2012) identified the environmental, predisposing, enabling and reinforcing factors (as the model highlights) for these behaviours through the literature and focus group discussions. A second study in which the PRECEDE construct also guided the reported intervention was by Creedon (2005). More specifically, the intervention targeted at improving HH compliance of healthcare staff of an ICU by focussing on two of the model's components viz., the behavioural and educational assessments. Interestingly, and as is the case in other studies as well, despite the established name of a theoretical approach (e.g. PRECEDE-PROCEED model) many authors have used the words 'theory', 'framework', 'model', etc. interchangeably to refer to a specific theoretical approach within their papers (in Creedon 2005 the PRECEDE model is referred both as theory and model).

Another theoretical approach used to guide the reported intervention towards improving HH compliance among nurses at a haemodialysis unit was the BASNEF model (Baghaei, Sharifian and Kamran 2016). Baghaei and colleagues highlighted that identifying the reasons behind people's practices and understanding what contributes to behaviour change are crucial. They, also, underscored the importance of identifying the 'enabling factors' that influence HH behaviour a component that is proposed by the BASNEF model. As raised previously, the BASNEF model has been described by the authors as model, theory and framework interchangeably.

Considering that the PRECEDE-PROCEED model and BASNEF model reflect on the individual's characteristics stemming from a psychological perspective, the bulk of the remaining theory-based interventions depart from a nursing practice, engineering or marketing perspective adopting systems-wide approaches. For example, Basinger (2014) introduced a comprehensive unit-based safety program (CUSP) aimed to reduce CLASBI in ICUs. The program was seen as an innovation for the participating teams rendering Roger's diffusion of innovation theory an appropriate approach to adopt. The CUSP aimed at providing education on safety issues, identifying defects and hazards and learning from them, establishing collaborations between senior executives and units and implementing teamwork and communication tools. Roger's diffusion of innovation theory that facilitated the implementation of the program was based on promoting five attributes namely the relative advantage of the program as perceived by the users, its compatibility to the norms of the participating groups, the observability of the results and the degree to which they are visible to users, the degree to which the program is perceived as complex or difficult to use and the degree to which the program can be trialled prior to its initiation and adoption.

Similar to Roger's theory, where an innovation is introduced into practice, the Iowa model of evidence-based practice facilitates the introduction of research evidence into practice. Considering that toys in neonatal ICUs can be a source for HAIs Hanrahan and Lofgren (2004) evaluated the practice of placing toys in a neonatal ICU in relation to HAIs by implementing the Iowa model of evidence-based practice. This model was used as a guide for the research team in decision making using a literature review, case studies, exploring scientific principles and theory and consulting key experts.

Reducing HAIs in an ambulatory dialysis unit from a systems-wide approach is described in a study by Lewis et al. (2014). The authors applied the sociotechnical systems framework placing particular emphasis on the interactions between people and the working environment (i.e., system) and identified discrepancies and risk factors that could lead to HAIs.

Drawing on quality improvement methods to bring about changes on a large scale, the following two studies adopted the PDSA cycle. More specifically, Linam et al. (2011) aimed at improving HH behaviour among healthcare staff in two paediatric units involving the introduction of leadership and team-based approaches reflecting the PDSA rationale. Similarly, Pulcini et al. (2007) aimed at decreasing VAP rates in an ICU unit highlighting that institutional support and leadership are key.

Another study that embraced the value of leadership and collaborative work is by Su (2016). The study aimed to reduce HAI rates in a surgical ward within 6 months. By implementing the principles of Kotter's model and using a co-design approach, Su (2016) addressed the importance of motivating healthcare staff to be involved and actively engage with the project and take ownership of the intended changes in their daily practice.

Martin-Madrazo et al. (2012) implemented a HH improvement strategy based on WHO's 5 moments for HH. Their strategy was implemented across 11 primary care settings with system change and education as key elements situated at the core of their strategy.

A variety of theories and related constructs as well as overarching guiding frameworks underpinned each of the remaining 6 interventional studies. Huis et al. (2013) adopted a blend of social learning theory, social influence theory, theory on team effectiveness, and leadership theory. More specifically, Huis and colleagues aimed to improve nurses' HH adherence across 67 nursing wards of 3 hospitals focussing on the importance of social influence in healthcare staff and strengthening leadership.

Another study that aimed to improve HH compliance among healthcare staff was by Fuller et al. (2012). The authors developed an intervention based on providing personalised feedback to healthcare staff about their HH across 60 wards (acute care of the elderly, general medical wards, and intensive therapy units). The development of the intervention was based on the TDF and MRC framework for complex interventions incorporating aspects of goal-setting (Locke and Lathame 1990), control (Carver and Scheier 2000) and operant learning (Skinner 1953) theories.

Harne-Britner, Allan and Fowler (2011) also aimed to improve HH compliance among nurses and personal care assistants across 3 nursing units based on change theory coupled with operant learning through staff education and positive reinforcement.

Curry and Cole (2001) intervened in the medical and surgical intensive units of a large teaching hospital to reduce VRE rates. Highlighting that VRE is a problem requiring healthcare staff's behaviour change the authors considered the 5 levels of influence including individual, interpersonal, institutional, community and public factors. They, also, explicitly referred to the use of aspects of the health belief model, social cognitive theory and ecological model through role modelling, observational learning and vicarious reinforcement.

Pontivivo et al. (2012) developed a HH intervention guided by the 5 moments for HH, the transtheoretical model and Pathman's model aiming to improve HH compliance and reduce HAI rates in a metropolitan teaching hospital (ICU, medical and surgical wards). These theoretical approaches underpinned the intervention through elements of coaching, competition, group evaluation and feedback and executive endorsement. It is unclear how the transtheoretical model informed the intervention, however the various stages of the Pathman's model were more clearly addressed in the implemented intervention.

Finally, the study by Sharma et al. (2015) focussed on the development and promotion of an in-house prepared alcohol-based hand-rub. This was achieved through a series of activities based on the PRECEDE-PROCEED model, the transtheoretical model, frontline ownership and social marketing. These approaches involved the active engagement of participating healthcare staff from a tertiary care teaching hospital in all stages of the process (from the formulation to implementation) denoting their strategic role in the acceptance of the test product (reflecting the PRECEDE-PROCEED model). Some of the aspects underpinned by the theoretical approaches included the development of handmade posters with healthcare staff involvement (frontline ownership), the implementation of the strategy based on the participants' stages of readiness to change (transtheoretical model) and producing an ABHR that is easy and cheap to prepare (social marketing).

3.4.4.2 How are these interventions structured and applied?

The vast majority of the identified interventions were multimodal (*n*=14) employing primarily behavioural, educational, and environmental overarching strategies and only one (Baghaei, Sharifian and Kamran 2016) described a single-component intervention. Particularly, the concept of education was a key aspect of the structure of the identified interventions and was applied in range of interventional activities or strategies including for example educational sessions with informative presentations among participating individuals and use of posters providing information about HAIs and IPC practice.

For example, Aboumatar et al.'s (2012) multimodal intervention included a multimedia communications campaign (multimedia, multidisciplinary posters, banners, stickers, screen saver), education (online course on HAIs, fact sheets, question-and-answer sets), environment optimisation (isolation signage, hand sanitiser placement), leadership engagement (via messages in communications campaign, HH leader guide and toolkit, tailored data reports, institutional leadership support letter), measurement of team performance and providing feedback on HH behaviour to healthcare staff (via HH monitoring system and rewards for high-performing teams, online reporting tool and public recognition of individuals as HH superstars). The program was part of a time-series study design and was implemented and assessed during a 3-year period.

Another multimodal intervention was reported by Creedon (2005) who used a quasi-experimental study design to implement an interventional HH programme including use of an educational handout and a poster campaign (i.e., provision of knowledge re the rationale for washing hands, info on HAI rates statistics and info on related costs for the healthcare system), use of ABHR and provision of HH behaviour feedback to participating healthcare staff based on pre-test observations. After the implementation of the programme (note that its duration is unclear based on the information provided) self-report questionnaires were administered to participants to elicit responses about attitudes, beliefs and knowledge in relation to HH compliance.

One of the included studies implemented a single-component intervention which was purely educational. More specifically, Baghaei et al.'s (2016) intervention was conducted among 70 haemodialysis nurses across health and educational centres. The experimental group in this controlled quasi-experimental study attended educational meetings (information on HH behaviour provided in booklets and CD). Participating nurses attended two sessions each lasting for 1 hour. Pre-, and post-intervention questionnaires based on the BASNEF model were also administered.

3.4.4.3 To what extent are these interventions effective?

With regards to the effectiveness of the identified interventions interesting observations were drawn considering primarily the reported study outcomes and study designs in conjunction with the authors' conclusions and statistical analyses provided where appropriate.

As shown in table 3.4, 8 out of 9 interventions led to statistically significant changes in HH compliance with 5 of them detecting sustained effects ranging from 6 to 20 months post-intervention. The predominance of HH interventions in the current review along with the positive outcomes regarding their effectiveness and sustainability corroborates the notion that improving HH is a simple and cost-effective way towards tackling HAIs (Herbert et al. 2013). Along with improved

HH compliance, the intervention by Huis et al. (2013) was also successful at decreasing the presence of jewellery and long-sleeved clothes among participating healthcare staff. Of the remaining studies, 9 targeted at decreasing infection rates, 1 targeted at decreasing surface contamination and 1 targeted at increasing the use of soap and ABHR among healthcare staff. All of these studies, apart from Basinger's (2014) study (focussed at decreasing infection rates), failed to provide either statistically significant results regarding the effectiveness of the reported intervention or even any statistical information thus rendering the decision to whether the intervention was successful or not very challenging. Interestingly, in the case of interventions targeted at decreasing infection rates, the concept of sustainability of the intervention effect was either unclear or even unexplored. However, the intervention implemented by Basinger (2014) reported a sustained reduction of HAI rates at 18 months post-intervention.

Although explanations about the selected theories were provided in the included studies, when looking at the potential relationship between theory and the effectiveness of the interventions only very few studies explicitly addressed the impact of the chosen theory to their study overall. For example, Baghaei, Sharifian and Kamran (2016) attempted to explain the failure of their theory-based intervention (use of BASNEF model) suggesting that the constructs of attitudes, intentions and self-reported practice might not successfully reflect on actual HH behaviour change (a notion suggested elsewhere too; Jenner et al. 2006). Baghaei, Sharifian and Kamran (2016), also, indicated that the educational nature of their theory-based intervention might explain this lack of success. In another study, the success of the team and leaders-directed intervention by Huis et al. (2013) based on theory principles of social influence, team effectiveness, role modelling and leadership was corroborated by the support given by the participating wards managers and their belief in the usefulness of the intervention on patient safety issues. This might suggest that when participants actively engage with and are motivated towards practice change initiatives it might lead to positive practice changes and successful outcomes. In addition, the success and acceptability of the in-house prepared ABHR by Sharma et al. (2016) was directly attributed to the use of frontline ownership approach in the implemented intervention. The authors, also, highlighted the contribution of the visual components of the intervention (i.e., visual portrayal and handmade poster) towards the acceptability of the product. This example suggests that creative and cost-effective methods along with leadership approaches may contribute to success. Along the same lines, Su (2016) suggested that empowering healthcare staff and giving voice to their opinions contributed towards HAIs reduction and a sustainable workplace culture. This success was directly linked to the use of Kotter's model (Kotter 2012) indicating the need for a collaborative approach and engaging leadership to encourage and motivate staff participation.

In relation to the number of outcomes addressed, the vast majority of the included studies reported on one outcome measure each with 4 studies including 2 outcomes. Interestingly, of the latter only the cluster RCT by Huis et al. (2013) was successful in improving both healthcare staff's HH compliance as well as the frequency of wearing jewellery and long-sleeved clothes. This might be an indicator that successful interventions can be those which address one outcome at the time considering that human behaviour can be very complex indeed.

Finally, a range of research study designs have been coupled with what it would be considered as less behavioural-based theories. For example, Martin-Madrazo et al.'s (2012) cluster RCT study (across 11 primary care settings) and Pulcini et al.'s (2007) quality improvement initiative (ICU team-based) adopted the 5 moments for HH and PDSA cycle respectively which led to successful outcomes. On one hand, this underscores the importance to consider less classical theoretical approaches when designing interventions, but it also highlights a gap regarding what the criteria and justifications should be when choosing the appropriate theoretical approach. As mentioned above, although authors provided explanations for the selection of the reported theoretical approach across the board, it was unclear why these particular approaches were favoured compared to others, why the particular intervention structure and content was chosen, and importantly how interventions can be improved in terms of effectiveness and sustainability. Acknowledging that it is challenging to address these questions within the confines of research papers with restricted word limits, they formed the basis for the next Phases of the current PhD study.

3.5 Discussion

3.5.1 Key findings

This integrative literature review was conducted in order to explore the wider context within which theory-based interventions have been applied for preventing and controlling HAIs or positively influencing related concepts (e.g. HH compliance) among healthcare staff. More specifically, it provides the first actual review of theory-based interventions in terms of *what*, *how*, and *how effective.*

In relation to the nature of theories, most of them were targeted at positively influencing the system and the wider context within which teams perform hygiene-related practices. These stem from less behavioural-based sciences including engineering and marketing (e.g. Sociotechnical systems framework, social marketing). Usually, such theory-based interventions are focussed on the whole organisation as a collective organism rather than at the individual characteristics of healthcare staff that underpin their behaviours. The review also identified more traditional and psychology-based theories looking at the integral aspects of human behaviour such as attitudes, social norms and stages of readiness for behaviour change (e.g. PRECEDE-PROCEED model, TDF, transtheoretical model). A final cluster of theories refers to those with a policy-, and guideline-orientation underpinned by a nursing evidence-based perspective. The Iowa model of evidence-based practice, the 'My 5 moments of HH and the PDSA cycles can be seen as examples of this cluster of theories.

Although it is helpful to establish the above clustering of identified theories in terms of categorising them into distinct groups, it may be more meaningful to approach the concept of effectiveness of theories in terms of their underpinning constructs. For example, a review by Weston, Hauck and Amlot (2018) explored the key behavioural constructs of theories that contribute to behaviours related to IPC practice. Amongst other things, the authors highlighted the importance of theories that incorporate social constructs (e.g. contact, imitation, norms). Importantly, what is key in the success of theories with such constructs is the relevance of these constructs and the desired behaviour to the individual's salient social group for achieving behavioural uptake (Weston, Hauck and Amlot 2018; Oyserman, Fryberg and Yoder 2007). By way of example, UK university students were found to engage more in health promoting behaviour when they perceived themselves as UK citizens (i.e., a comparatively healthy social group) rather than as being students (i.e., a comparatively unhealthy social grouping) (Tarrant and Butler 2011). Taking the above into consideration and in light of this review's findings answering a potential question of 'what is the best theory or theories in the context of HAIs and IPC?' may not be an easy one to answer. What seems to be important for an intervention to be effective is based on addressing a complex set of dimensions influenced on an individual, group/team and organisational level.

Furthermore, it is interesting to note that the majority of studies adopted single theories as the sole point of reference for the implemented interventions which were strongly characterised as being multicomponent. With regards to the former point, this indicates that using one theory only seems to be the popular approach and might be more beneficial than a combination of theories when developing, implementing and evaluating interventions. This provided the basis to argue that this combination (i.e., single theories and multicomponent interventions) is potentially the most effective. However, this observation contradicts Glanz and Bishop (2010) who suggested that the strongest interventions may be those developed by multiple theories underlining that the unique contribution of the theories adopted must be clearly thought through. Glanz and Bishop's latter point highlights that due care must be exercised since there was often a lack of explicit justifications for the use of the chosen theories in the identified papers. With this in mind, more definitive conclusions could have been drawn if such explanations have been provided by the authors.

As can be seen in table 3.4 the vast majority of theory-based interventions that were successful were targeted at improving HH practice. Of them, 3 studies achieved a sustained effect: one utilising the PRECEDE model (psychology-based), one utilising PDSA cycles and one the 'My 5 Moments of HH' (both regarded as policy-, and guideline-based approaches). Taking the above into consideration it is very challenging to definitively argue which theory cluster as presented above has the potential to lead to positive and sustained effects. However, the evident success of interventions that aimed to improve HH may indicate that the adopted theories are appropriate thus leading to positive outcomes. In other words, the successful use of theory can be determined by setting behaviour change goals on a lower and more feasible scale (as in the case of HH) compared to setting goals on a larger, institutional-based scale (as in the case of decreasing infection rates). In addition, the presence of 2 (out of 3) policy-, and guideline-based theoretical approaches leading to sustained effects in HH may be an indicator of this cluster of theoretical approach. However, this needs to be interpreted with caution as it is not a representative sample of the included studies.

Considering the wide range of geographical settings where studies were conducted denotes that HAIs-related research is of global importance. The majority of research was conducted in developed countries (predominantly in USA, UK and Australia) with two studies from resource-limited countries indicating that more research is required in those areas. Interesting insights are, also, provided by the types of clinical settings. More specifically, healthcare staff were recruited from various clinical environments ranging from single hospital-based units to large tertiary care teaching hospitals. Based on the available data, the studies were conducted across 54 acute care hospitals, 8 teaching hospitals, and 17 primary care settings. Within them, ICUs were the most popular clinical areas (n=92), followed by surgical (n=28) and medical (n=27) wards.

The predominance of ICUs in the studies highlights that addressing the HAIs challenge and improving IPC practice in this clinical area is a high research priority. This is especially key in light of the need for high quality of care for the vulnerable patient population admitted in ICUs (Wenham and Pittard 2009). However, the small number of other selected wards including paediatric units (n=11), haemodialysis units (n=2), an ambulatory dialysis unit and an oncology department highlights the need for further research in these clinical settings. It is unknown exactly how many or what specific clinical wards were involved in the study by Sharma et al. (2015) as the authors focussed and reported on the whole participating institution.

The exact number of healthcare staff reported in these studies cannot reliably be determined owing to the observational nature (e.g. observations on HH opportunities and practices) of the majority of the studies and lack of explicit information about the participating healthcare staff. The multicomponent nature of the studies is reflected on the variety of components identified across the 16 studies providing a ‘palette’ of overarching component themes and specific components that guided the development and implementation of the reported interventions. Although, the variety of components used may offer a potentially useful ‘menu of options’ the importance of individual components could not be assessed nor speculated as authors acknowledged themselves (e.g. Aboumatar et al. 2012; Creedon 2005). Interestingly, Linam et al. (2011) highlight that multimodal interventions that directly reflect on healthcare staff’s behaviour can result in improved outcomes compared to single-component interventions based on education and provision of supplies only. In addition, they stressed the importance for establishing a culture of change within healthcare teams as being crucial for sustained improvements and which can be achieved when HH compliance becomes a social norm. This seems to tightly link to the importance of leadership and the value of considering the problem of HAIs from a systems-, and team-based perspective (Saint et al. 2010; Wong and Briggs 2018) as emerged from this IR.

3.5.2 Interpretation of key findings

The recently published Public Health England (PHE) Behavioural Science strategy (PHE 2018) articulates the vision of integrating social and behavioural science approaches into the process of developing effective interventions (including planning, delivery and evaluation). This endeavour is crucial towards the improvement and protection of people’s health and establishing a behavioural and social science community championing best practice. Such a science is seen as an amalgamation of various approaches and methods stemming from psychology, nursing, anthropology, economics and marketing amongst others (Glanz and Bishop 2010). In other words, of central importance in this strategy is the harnessing of transdisciplinary approaches where answers to public health issues are not given from a discipline-specific perspective but instead draw on insights from the behavioural and social sciences (PHE 2018a). This vision has in part been reflected in the current IR as different disciplines and approaches have been adopted in the identified studies for tackling HAIs and positively influencing related behaviours.

The suggested adoption of transdisciplinarity by PHE mirrors on one hand the complexity of the processes when promoting and safeguarding public health and highlights on the other the complexity of human behaviour. For example, this

IR revealed that the majority of interventions aiming to improve HH were successful whereas those that aimed to reduce or eliminate infections largely failed. This finding indicates that there might be a number of factors in the wider healthcare environment that can impinge on healthcare staff's practices and thus need to be considered carefully when developing pertinent interventions. This finding is in line with a systematic review on the effectiveness of interventions to improve HH compliance among nursing staff (Doronina et al. 2017) suggesting that healthcare staff are able to change their behaviours indeed and that issues related to the system can also explain failures in staff's practices and adherence to guidelines.

3.5.3 Strengths and weaknesses of the integrative review

This very first endeavour to map such a wide field, both in terms of the extensive nature of theories included as well as the range of study outcomes, provides an in-depth and thorough presentation of interventional studies. Such an endeavour is crucial, on one hand, for enriching the evidence base and guiding related research and for informing the next study phases of this PhD work, on the other. Another strength of this review is the methodological rigour, the thoughtful procedures and the established tools adopted as well as the valuable input provided by external advisors (e.g. with expertise in integrative literature reviews). These actions taken provided objectivity to the whole process and ensured that publication and selection bias was minimised. The preparation of a protocol prior to the formal initiation of the current IR, also, facilitated the research process overall.

The inclusion of a range of experimental and non-experimental studies of varying quality may be seen as a limitation; especially since the use of narrative analysis may mean the synthesis of the findings could potentially be subject to author bias. Taking this into account a meta-analysis could have reduced such a possibility however acknowledging the aim and objectives of the current exploration the integrative review was deemed as the most appropriate method. Finally, the review was restricted to peer-reviewed studies and those written in English only.

3.5.4 Reflections and future direction

The current IR was initially conceptualised and designed at the commencement of the current author's PhD journey and was part of a primary aim to develop and pilot-test a theory-based and visualisation-centred (see next Chapter 5) intervention among healthcare staff. It was thus envisaged that the findings of this review would facilitate this endeavour in terms of providing definitive answers regarding mainly what theory to use and how, as well as what its content (e.g. components) should be. As the review was progressing it became evident to the author that the understandings derived about theory use provided a very useful basis from which to proceed to examine the use of visualisation. Interestingly, very few studies of this IR implicitly referred to the use of any visualisation as part of the reported interventions (e.g. Creedon 2005; Sharma et al. 2015). As a corollary, the doctoral research aimed to investigate in depth issues related to selection and justification of theory (current Chapter) and visualisation approaches (Chapter 4) leading to consult key experts as part of a Delphi study (Chapter 5) and conducting focus group discussions with healthcare staff (Chapter 6).

The lack of clear justifications regarding the selection of theory in the identified studies was the principal finding that triggered the initiation of this route. This was corroborated by Michie and Prestwich (2010) who recognised that theory in the wider behavioural science context is very frequently used as a 'loose framework' with authors failing to clearly articulate how theory was used to inform the intervention.

The findings from the current Chapter along with Chapter 4 have formed the basis for the conceptualisation of the Delphi study (Chapter 5) and are reflected in its round 1 questionnaire. The subsequent Chapters provide more detailed information about how this was achieved and describe the links of the thesis chain.

3.6 Conclusion

The current mapping of theory-based interventions in the field of HAIs offers an extensive presentation of theories adopted to develop and implement interventions, components that were integrated in those interventions as well as describes how they were structured and applied. Its value is, also, based on the exploration of the effectiveness of interventions and thus the adopted theories. The decision as to whether a theory is suitable or not for substantively informing an intervention comes through scrutinising the underpinning constructs of the theory and their relevance to the targeted population and clinical context. Arguably, the aggregated heterogeneity of evidence in this review serves the primary objective to identify theory-based interventions and map their wider context. Nonetheless, the complexity of, and in some cases incompletely reported evidence reflected on hygiene-related behaviours (e.g. HH), healthcare settings, study outcomes and study design as identified in this review highlights the need for more and in-depth justifications.

Chapter 4

Integrative Review 2

CHAPTER 4

VISUALISATION-CENTRED INTERVENTIONS IN THE FIELD OF HEALTHCARE-ASSOCIATED INFECTIONS: AN INTEGRATIVE REVIEW

4.1 Introduction to the Chapter

This chapter reports an integrative literature review of visualisation-centred interventions that aim to positively influence the prevention and control of HAIs among healthcare staff. As in the case of the previously conducted IR (Chapter 3) the synthesis of the findings is based primarily on a narrative approach facilitated by the use of visual diagrams to present the findings as well as to inform and design the subsequent research phases.

4.2 Background

As noted in Chapter 1, the adoption of visualisations in interventions towards the promotion of behaviour change has been embraced across a range of healthcare research areas. The adoption of visualisations can be seen as either a complementary or a central focus approach that aims to promote behaviour change.

Orji, Vassileva and Mandryk (2012) who used a behavioural perspective towards effective health intervention designs argued that *"one of the main difficulties one encounters when attempting to motivate people to adopt a healthy behaviour is the invisible immediate and short-term benefit and consequences of many health behaviours."* (Orji, Vassileva and Mandryk 2012 p. 9). Therefore, and in response to their argument, the use of visualisations in pertinent interventions related to the behaviour under investigation could potentially aid individuals to better consider the benefits and consequences of their behaviours.

In the case of IPC, a central challenge in comprehending related behaviours (e.g. HH) lies in the fact that the pathogens which are the causal factor of HAIs are invisible to the naked eye (Macduff et al. 2014). This invisible nature of HAIs coupled with the complexity of the healthcare system (Lipsitz 2012) may thus render addressing the concept of HAIs and IPC especially difficult for achieving behaviour change. Such a challenge is attributed to not only the invisibility of pathogens but also the lack of any immediate feedback on the consequences of sub-optimal practice e.g. hand washing where the consequences are not immediately visible.

On the same basis, further research sought to explicitly investigate the role of visualisation and ideation relating to HAIs within the wider IPC context. For example, Macdonald and Macduff (2018) aimed to investigate the contribution of the arts and humanities to the prevention and control of HAIs through the establishment of a cross-disciplinary network. Their study involved a network panel of academics and professionals from various disciplines (e.g. social policy, nursing, psychology, sociology, graphic design, health humanities) and was focussed on addressing the central question of "*how can we better address the problem of HAIs through visualisation-related ideation and applications?*" Macdonald and Macduff's (2018) study highlighted that the nature of the concept of visualisation is expansive reflecting on a range of phenomena from invisible pathogens (i.e., 'micro' world phenomena) through 'visible' clinical practice and social policy (i.e., 'macro' world phenomena). This proposition thus denotes that visualisation can be a process or a product in the IPC context that can facilitate the promotion of pertinent practices. The authors, also, noted the importance of cross-disciplinarity in visualising the concept of HAIs and highlighted that developing and implementing various perspectives stemming from collaborative work could help towards better addressing the problem (Macdonald and Macduff 2018).

The increasing momentum on the adoption of visualisation-centred approaches is, also, reflected on continuing calls and initiatives by UK Research and Innovation (UKRI) (2019) in the field of IPC. Specifically, more than £2m was awarded in 2017 to arts and humanities researchers on a national scale in order to undertake innovative approaches to tackling AMR. The Council's decision to provide these awards highlights on one hand the importance of IPC in its wider context and embraces the need for collaborative and innovative research approaches, on the other.

4.2.1 Problem statement

The concept of visualisation, as an innovative approach, is increasingly researched and adopted towards aiding IPC and tackling HAI while being highly promoted by national funding bodies (e.g. UKRI, AHRC). Yet the nature and scope of visualisation-centred interventions as well as the wider context within which they have been implemented in the IPC and HAI context remain largely unknown. In addition, an initial scoping of the literature as part of this PhD study revealed an interesting variety of visualisations used in interventions of different types within the HAIs field. This integrative review was thus conducted to explore, and report research related to visualisation-centred interventions in the field of HAIs and thus address this evidence base gap. This integrative review aims to provide foundation for further research and developments within this dynamic field.

4.2.2 Database search for any pre-existing review

No other type of review of the same or similar scope to the current one has been conducted as shown by a search performed in the following databases prior to the formal initiation of the IR: The Cochrane Database of Systematic Reviews, the Database of Abstracts of Reviews of Effects (DARE), the Centre for Reviews and Dissemination, Web of Science, AMED, CINAHL, ERIC, MEDLINE and PsycARTICLES.

4.2.3 Review question

Given the absence of any previous systematic enquiry in this field the overarching research question guiding the current integrative review was, '*What research evidence exists around the development of visualisation centred interventions to aid healthcare staff prevent and control healthcare-associated infections?'*

Consequently, sub-questions to be addressed were:

1. What visualisation-centred interventions have been implemented?
2. How are these interventions structured and applied?
3. To what extent are these interventions effective?

4.3 Methods

4.3.1 Integrative review team

As in IR1, the PhD candidate designed and undertook all stages of the review with support from the three members of the supervisory team who each made particular contributions at key stages as explained below.

4.3.2 Study design

This study, as in in the case of IR1 (Chapter 3) is an integrative review of published studies. The IR adheres to the principles of Whittemore and Knafl's (2005) integrative review methodology. The conceptualisation of the IR, its aim and intended design at the preliminary formation stages have been described in detail in a protocol registered with, and published on the PROSPERO International Prospective Register of Systematic Reviews (Centre for Reviews and Dissemination - University of York) with a registration number: CRD42017048142 (Tsattalios et al. 2017). The design of the protocol and reporting of the current integrative review was guided by PRISMA-P (Moher et al. 2015) and PRISMA (Moher et al. 2009) statements respectively.

4.3.3 Inclusion and exclusion criteria

4.3.3.1 Operational definition of visualisation

For this review, visualisation has been operationally defined by the current author as:

"The creation and/or deployment of visual artefacts (such as static or dynamic imagery), and/or the stimulation of guided mental imagery, used as the central, substantive focus of an evaluated intervention within education, practice development/quality improvement or research in order to prospectively and positively influence healthcare staff to prevent and control healthcare associated infections (excluding visual artefacts used primarily for purposes of microbiological detection or surveillance, and written text based artefacts without a central focus on substantive integral visual imagery)."

4.3.3.2 Types of intervention

Articles were eligible for inclusion if they described an implemented intervention (or improvement programme or strategy or guidelines) making explicit and substantial use of a visualisation approach that aimed to help healthcare staff prevent and control HAIs.

Visualisation-centred interventions were regarded as those interventions that used central and substantive visualisations referring to interventional studies comprised either of a single visualisation component (i.e., single-component interventions) or interventional studies comprised of more than one visualisation components (i.e., multi-component interventions) reflecting use of 50% or more of the overall intervention and have been subject to specific evaluation. More specifically, in the absence of any convention from previous reviews, a decision was taken (after a scoping and testing exercise) to operationally define "central and substantive" as appearing to comprise at least 50% of the overall intervention.

With reference to the approach taken by Davis et al. (2015b) for single-component interventions the evaluation data would naturally relate to the visualisation-centred intervention so this information would be reported unless any other reason not to. Multi-component studies with 50% or more of visualisations in the intervention would only be included if there was specific data reported relating to the specific effectiveness of the visualisation component(s). The agreed effectiveness here could range from participants saying they liked the intervention through to decrease in infection rates if either are directly attributed to the visualisations alone through the study design.

The operational definition of visualisation along with a preliminary screening of search results were very important towards the exclusion and inclusion of potential studies. Specifically, a number of important points were drawn and formed the basis for the formal screening of the identified studies:

- Interventional studies that comprised different visual artefacts (e.g. flashing lights, posters, etc.) were regarded as integrated visual interventions. This observation and distinction of interventions was helpful in categorising interventional studies into single-component and multi-component interventions as described below.

- Multi-component interventions (i.e., using a mix of visual artefacts and other techniques; educational interventions using training sessions, educational seminars, posters etc.) were included only if visualisations appeared to comprise at least 50% of interventions and specific evaluative evidence was provided for the types of visualisations presented.
- Teaching modules/sessions as part of educational programmes were not necessarily regarded as visualisation-centred interventions just because they were in an electronic/online format.
- Studies using in-person simulations/demonstrations of skills were not considered as visualisation-centred interventions unless they had an explicit focus on eliciting specific mental images among participants.

Based on the aforementioned definition and points, studies were included if: the reported visualisation/s were the central and substantive focus of the evaluated intervention within a hospital clinic/unit/department or an educational setting, visualisations (as defined previously) were part of an interventional study or strategy where participants were exposed to and engaged with – either consciously or subconsciously – these visualisations.

Studies were excluded if: the intervention was multimodal/multi-component with visualisations not being the main focus of the intervention (i.e., appeared to be less than 50% use), the visualisations were used primarily for purposes of microbiological detection or surveillance, or automated cleaning of the hospital with no direct and active involvement of the healthcare staff, and the intervention did not have some sort of evaluation.

4.3.3.3 Types of participants

Studies which reported: healthcare staff (e.g. physicians, nurses, health visitors, support workers medical educators, etc.) and/or ancillary staff (e.g. domestic staff, catering assistants, etc.) and/or academic student population from health-related disciplines (e.g. nursing, midwifery, etc.) were considered for inclusion in the current review. Studies that recruited other types of participants (e.g. hospital visitors) in addition to healthcare staff and/or student population from allied healthcare disciplines, were excluded if there were no separate evaluative data for the different types of participants in the sample. Studies were excluded if the studied population comprised patients, visitors or policy makers only.

4.3.3.4 Types of outcomes

The types of outcomes in this review are in concordance with the ones described in IR1 (Chapter 3). These ranged from raising awareness of HAIs and hygiene practices of IPC, to increasing intentions to behaviour change, to increasing compliance to hygiene regulations, to improving the HH technique, to decreasing infection rates and sustaining the related behaviour change. Any other types of outcomes along the above lines were discussed within the review team to decide if were eligible for inclusion.

4.3.3.5 Types of settings

Included studies involved interventions and/or strategies implemented in primary, secondary and tertiary healthcare settings as well as healthcare in the community. Studies reporting similar settings not included in the above list were also considered for inclusion as long as their context belonged to the healthcare context. Interventional studies conducted in microbiological settings with a specific focus on microbiological detection/surveillance were not considered for inclusion. Finally, studies whose setting was not related to the hospital/healthcare and/or university/educational environment were not considered for inclusion.

4.3.3.6 Study designs

In order to adhere to the 'spirit' of the integrative review methodology and capture as a wide range of visualisation-centred interventions as possible, this IR considered for inclusion any study of qualitative, quantitative and mixed-methods designs. Studies were, also, initially considered for inclusion both if they were of explorative nature or of less interventional character whose focus was to explore healthcare staff's perceptions and opinions of visualisation approaches. Studies were not ruled out or in, on the basis of whether they were pilot or feasibility studies. Similarly, studies were not ruled out or in, on the grounds of being a validation study. However, studies were ruled out on the specific grounds that they were calibration studies, i.e., studies where the sole or primary aim was technical calibration of the reported tool through validation against an existing specified standard.

Finally, systematic reviews, expert opinion articles, letters to the editor and conference proceedings were excluded from the review, however, whenever identified their references were screened for other eligible studies. Articles not written in English were excluded. Finally, no restrictions to the studies' quality were applied. The aforementioned inclusion and exclusion criteria used are summarised in table 4.1.

Table 4.1. Summarised inclusion and exclusion criteria for papers

	Inclusion criteria	Exclusion criteria
Types of visualisation-centred interventions	Substantial use of visualisation (i.e., 50% or more of the overall intervention)	No substantial use of visualisation
	Having the intention to positively influence healthcare staff	Other than having the intention to positively influence healthcare staff
Types of participants	Any healthcare and ancillary staff as well as academic student population from health-related disciplines	Non-professional healthcare related participants being the sole participants of the study (e.g. patients only)
Types of outcomes	Raising awareness of HAIs and hygiene practices of IPC, increasing intentions to behaviour change, increasing compliance to hygiene regulations, improving the HH technique, decreasing infection rates and sustaining the related behaviour change	Any outcome out with the nature of the continuum.
Types of settings	Primary, secondary, tertiary as well as 'healthcare in the community'	Any 'non-healthcare'-related setting
Study designs	Both experimental and non-experimental studies of qualitative, quantitative or mixed-methods nature	Reviews, discussion papers, letters to the editor, proceedings, published abstracts
	English language	Non-English language
	No restriction to the quality of the studies.	
Publication date	Published after January 2007	Published before 2007

4.3.4 Search strategy and database sources

4.3.4.1 Piloting the screening process

As part of the search strategy, it was key to first pilot the screening process in order to ensure clear operational understandings. The formal search strategy was refined and decided through iterative team feedback and guidance including consultation with a librarian. This included the combination of four key search terms, namely 'visualisation', 'healthcare-associate infections, 'intervention' and 'prevention and control'. An initial combination of these terms was performed on Web of Science with no restriction on publication year resulting in 357 papers.

The purpose for performing this search was twofold. On one hand to develop an initial picture of the nature of published studies by conducting three 'tests abstract screening' of the retrieved papers (i.e., random selection of three blocks of abstracts with 10, 10 and 20 abstracts in each block respectively). On the other hand, it aimed to help finalise the inclusion and exclusion criteria as described above. The three abstract exercises were conducted independently by two reviewers (KT, CM) using a mutually agreed screening grid. The use of the screening grid aimed to capture key information from each abstract including:

- Paper ID, authors and date of publication
- Whether visualisations were central
- Whether the study involved an implemented intervention
- Whether the study had a focus on HAIs
- Whether the study reported on healthcare staff or student population
- Whether evaluative data were provided?
- The setting of the study

Apart from the aforementioned important information, the screening grid also included three more columns: a section with the reviewers' decision to include the study or not, a section with the reviewer's comments and a classification section similar to the one used in IR1. For the purposes of the current review this classification system included the classification of studies (based on their abstracts) as 'Model' and 'Contrary/No' cases. Model cases referred to those studies that based on their abstracts could qualify for further screening-accessing full papers and were classified in the following 4 sub-cases:

- Model 1 cases (M1) = studies reporting on subconscious intervention or engagement by participants– not overt
- Model 2 cases (M2) = studies reporting on conscious engagement with intervention/training program by participants, but none or unclear if additional feedback given to participants
- Model 3 cases (M3) = as above but with feedback given to participants
- Model 4 cases (M4) = discretional selection of the study in order to get and review full paper – indication that the study might fulfil the established inclusion criteria but access to full paper is required

Contrary/No cases (C) referred to cases of studies entirely beyond the scope of the current review that could not be classified at any of the aforementioned categories ('yes/no' sections in screening grid were all ticked as 'no').

4.3.4.2 Final screening process

Along with finalising the inclusion and exclusion criteria as already noted, the completion of the abstract exercises aided the review team to finalise the search strategy including a full list of synonyms for each key term. Index terms were not used in the search process. More specifically, the Boolean search string used was as follows:

1. "**healthcare-associated infection***" OR "healthcare associated infection*" OR "hospital-acquired infection*" OR "hospital acquired infection*" OR "nosocomial infection*" or "hospital infection*" OR HAI OR HAIs OR HCAI OR "HH"

   AND

2. **visualisation*** OR visualization* OR graph* OR poster* OR "visual tool*" OR "visual graph*" OR "visual display*" OR "virtual" OR "visual cue*" OR "visual reminder*" OR image* OR presentation* OR icon* OR table* OR picture* OR photograph* OR light* OR "internal image*" OR "external image*" OR "mental image*" OR video*

   AND

3. **intervention*** OR strateg* OR approach* OR "improvement program*" OR education* OR train*

   AND

4. "**prevention and control**" OR prevent* OR control* OR adherence OR compliance

The formal search strategy applied the above search string (i.e., 1. AND 2. AND 3. AND 4.) across Web of Science, and through EBSCO interface AMED, Arts & Architecture Source, CINAHL, MEDLINE, PsycARTICLES, ERIC, American Doctoral Dissertations, SocINDEX and SPORTDiscus. In addition, based on the previous scoping and the abstract exercises, it was evident that the majority of the potentially relevant papers were published within the last decade. For this reason, it was decided that the formal search would include published studies from 1st January 2007 to 9th May 2017 (date when formal searches were last performed).

4.3.4.3 Study selection

The number of retrieved studies from the initiation of the formal search through the final selection are depicted using a PRISMA Flow Diagram (Moher et al. 2009) as shown in figure 4.1.

4.3.5 Data extraction

Data from the studies selected for final inclusion were captured using an extraction table. The extraction Table was divided in columns where each article's important information was entered as appropriate: Study details (i.e., author and year of publication), country, purpose, type of visualisation, population and setting, design and intervention, duration of intervention, outcomes, findings, and author's comments and/or limitations.

4.3.6 Quality assessment

As in IR1, the various CASP (2014) tools along with the QATSDD (Sirriyeh et al. 2012) tool were used to assess the quality of the included studies in the current review as appropriate. As quality improvement studies were identified through the abstract exercises it was decided to use the Quality Improvement

Minimum Quality Criteria Set (QI-MQCS) (Hempel et al. 2015) to assess quality of such studies which do not necessarily adopt an experimental-based procedure.

4.3.7 Data synthesis

Whittemore and Knafl's integrative approach guided the overarching review process and Popay et al.'s (2006) narrative synthesis along with visual diagrams where appropriate were used to synthesise the study findings.

4.4 Results

4.4.1 Study selection

All database searches, both during the scoping exercises and formal initiation of the review, were performed by the PhD student (KT). Of the initial 557 papers identified after combining the four key search terms through the database searches (204 papers through Web of Science and 353 papers through EBSCO host) 160 duplicates were removed. The abstracts of the remaining 397 papers were reviewed independently by two reviewers (KT, CM) using the previously adopted screening grid to decide whether or not to retrieve the full text of the papers for further review.

Following abstract review, a further 338 papers were excluded thus resulting in 59 papers qualified for full-text retrieval. Of those 59 papers, 23 were included in the final IR (see table 4.2). The excluded papers (*n*=36) were ruled out for reasons related to:

- Full-text not being available (*n*=4)
- Visualisations were less than 50% of the reported intervention (*n*=12)
- Participants were not healthcare staff or students of health-allied disciplines (*n*=2)
- Reported intervention referred to the calibration of a tool (*n*=3)
- Absence of specific evaluative data for the reported visualisations (*n*=15)

The study search process and phase results are presented in figure 4.1. The retrieved titles and abstracts from all databases were entered into RefWorks software to allow for the deletion of duplications and to facilitate the retrieval of the included studies' full-text.

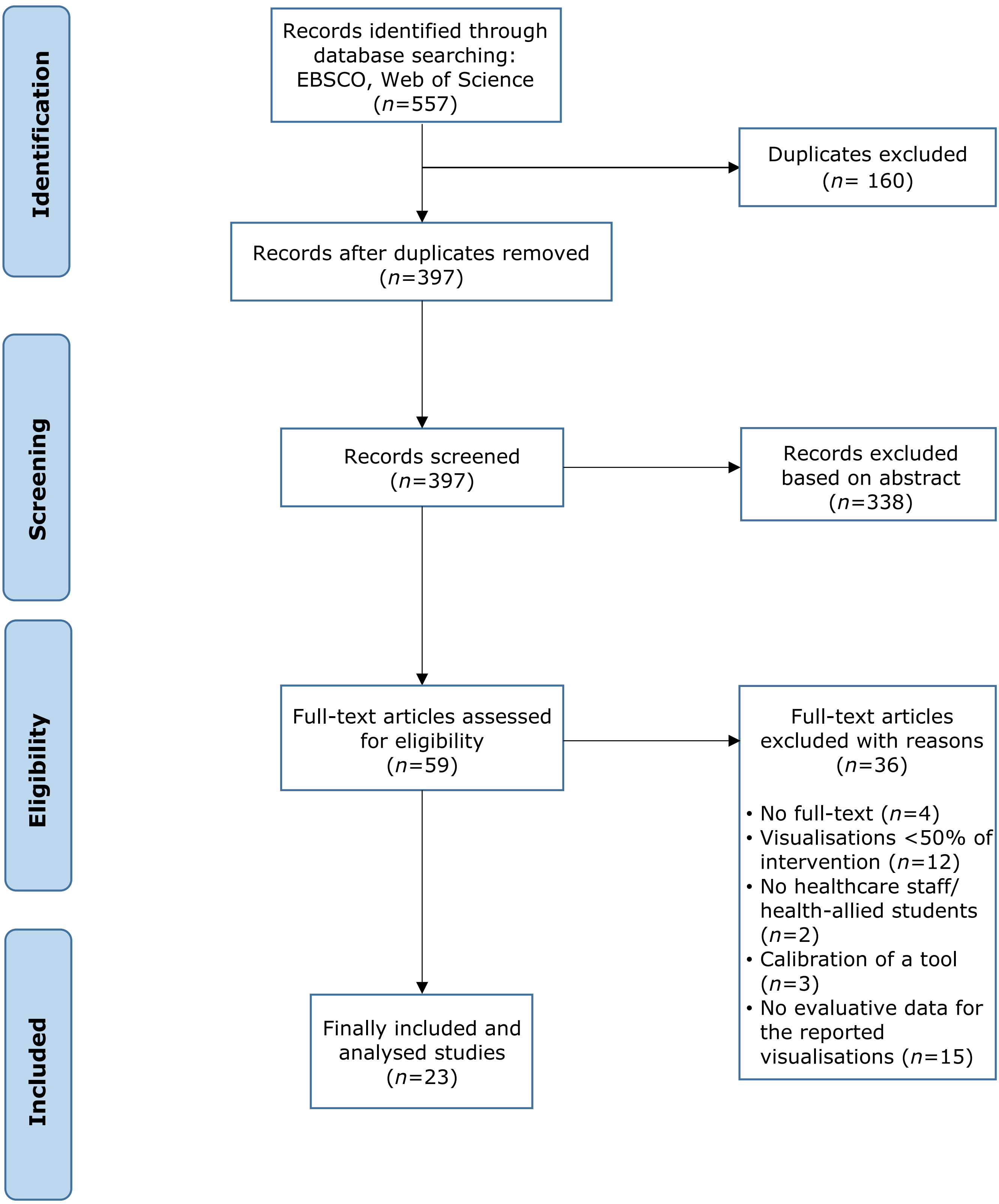

Figure 4.1 Study search process and phase results for IR2 using PRISMA Flow Diagram (Moher et al. 2009)

The reviewers' inter-rater agreement was determined regarding the study classification (i.e., M1, M2, M3, M4, C) and whether to access the full text of the studies or not. The agreement level for study classification achieved a Cohen's kappa (κ)=.80 (p<.001), and for accessing the full text received a Cohen's kappa (κ)=.90 (p<.001). These levels of agreement are conventionally seen as strong and very strong, respectively (McHugh 2012).

4.4.2 Generic description of studies

The following sections provide details about the generic characteristics of the included studies regarding their origin, methodology and methods, population, intervention settings, outcomes and study quality. Those studies that were excluded after full-text screening along with reasons for exclusion are presented in Appendix 5.

4.4.2.1 Study origin

The included studies were predominantly conducted in the USA (n=10) followed by the UK (n=2), India (n=2) and Australia (n=2), and one each in Mexico, El Salvador, Switzerland, Hungary, Netherlands, Thailand and New Zealand (table 4.2).

Table 4.3. Extraction table with characteristics of included studies in IR2 (table continues until page 125).

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Assanasen et. al 2008 Thailand	To determine the relative impact of 2 different levels of feedback on compliance with infection control process measure in an ICU setting	Colour posters in the form of a dashboard: a graphical tool for displaying compliance with process of care measures; use of red, yellow, green colours	ICU HCWs (mainly nurses, physicians): not exact number provided.16-bed medical ICU and a 18-bed surgical ICU of a tertiary care teaching hospital	Quantitative; Multi-component; quasi-experimental; In phase 3: posters in highly visible, staff-only areas of the ICU. Compliance targets were specified in the dashboards: 60% for HH, 90% for head of bed (HoB) elevation, and < 10% for the proportion of FC use. Colour as a ''snapshot'' of goal achievement: red indicated poor compliance, yellow indicated borderline compliance, and green indicated acceptable compliance. Additional information provided, e.g. number of HAI per unit and the estimated cost associated with these complication and a summary of infection control risk reduction practices.	3 study phases: from April 2004 – June 2006. Colour poster in phase 3: July 2005-June 2006:1 year	HH, head of the bed elevation, femoral catheter use	Posters bypassed unit management and provided direct feedback to HCWs→HH:47%->71% ($p<.001$), HoB: 88%->93% ($p<.001$), no change in catheter use	No control group; shorter duration of phase 1 compared to 2 and 3; limited HH observations and low response rate in survey; no generalisability
Beam et al. 2014 USA	To evaluate the isolation behaviours of nurses for airborne and contact precautions in a simulated patient care setting.	Behaviour modelling and dialogue: video recordings of nurses after a simulation patient care scenario and think aloud review by participants	24 nurses (3 men) in academic health science centre	Mixed-methods; Single-component; After completing the simulation experience nurses were asked to think aloud as they were watching their video recording; they were cued on certain behaviour (cleaning the computer workstations, use of N95 respirator); CDC guidelines for PPE use given to nurses to review/comment;	Not clear how long the intervention lasted; follow-up e-mail at 1 month with a short open-ended 3-question survey	PPE IP-related behaviours;	Nurses completed the follow-up survey felt the simulation experience positively changed their clinical practice immediately	Small sample size; 1 institution
Birnbach et al. 2016 USA	To compare the efficacy of a CDC HH sign with an optimized intervention sign, which utilized evidence-based constructs. Both also compared with a ''baseline sign'' that included minimal evidence-based constructs.	Signs in the form of colour posters with some text included	82 physicians and 98 nurses observed for HH compliance; ICU	Quantitative; Single-component; Quality improvement study; Nurses and physicians observed for HH compliance rates when entering the ICU; baseline rates obtained prior to posting the two intervention signs.	Observations throughout the day over a 4-week period; each sign posted for 4 non-consecutive days	HH compliance	Total HH compliance rate was 16%; not significantly different among the signs; no difference among the signs for physicians or nurses.	HH observed upon entry only; a larger sign with more info and greater visibility might have produced different results; other technology could be used (e.g. flashing lights); participants not interviewed

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Caniza et al. 2007 El Salvador	To compare the efficacy of 2 educational tools	Videotapes and flipcharts	67 nurses of a paediatric hospital	Quantitative; Single-component; Videotape and flipchart created to convey the importance of HH: when and how to practice it effectively; use of alternatives to traditional handwashing; how to protect hands after washing; flipchart 10 min; videotape run for 7min. Multiple choice knowledge test before-after the presentations.	4-week course; use feedback for the flipchart obtained after 6 months	HH related knowledge	Greater improvement over baseline in Qs 2, 5, 7, 8 after video, and greater improvement in Qs 5, 8, 10 after flipchart; user feedback for flipchart only with a 6-item questionnaire: they said it was easy to use and durable, text easily visible-readable, clear content; overall success unclear as not all answers showed improvement	Low reliability of the testing instrument (Cronbach's alpha .40); video-based instructions were delivered to a single large group, whereas the flipcharts were used in 6 small groups.
Diegel-Vacek et al. 2016 USA	To assess an automatic sink light a prompt for clinician HH (interest was in the design intervention as behaviour prompt not in HH per se)	Automatic sink light	Healthcare clinicians (any hospital healthcare worker entering patient room) in a 28-bed cardiac unit; no specific professions recorded	Quantitative; Single-component; Pilot study: prospective, longitudinal observational study; In one inpatient room, clinicians were exposed to a HH reminder that consisted of a light turning on over the sink as they entered. The control room (the adjacent patient room) did not have the intervention of the light as a HH reminder; direct observations; theory-based	The light signal remained operational for 21 days; 3 observational days: day 1, day 14, day 21	HH compliance	88 clinician encounters were monitored; HH performance-Day (controls-intervention gr): Day 1 (7%-23%), Day14 (16%-30%), Day 21 (23%-23%). No statistical significance mentioned	Staff aware of observation times; night-time observations not included; even simple interventions aimed at staff behaviour change may have a direct and unanticipated impact on patients
Kukanich et al. 2013 USA	To improve HH in 2 outpatient health care clinics through the introduction of a gel sanitiser and an informational poster.	Poster (along with gel sanitiser)	HCWs; an outpatient oncology clinic and an outpatient gastrointestinal clinic	Quantitative; Multi-component; introduction of gel sanitisers and an informational poster to each clinic; the poster created to increase awareness of HH, provide info about when HH should be performed, encourage them to take personal responsibility for reducing the spread of HAI; poster created with brainstorming with clinic admins, nurse managers, research team.	1 week after the intro of intervention → direct observations of HH performed on 5 non-consecutive days, for 4 hrs/day; 1-month follow-up (gel-poster removed) on 3 non-consecutive days for 4 hrs/day; 3 months after last follow-up survey was mailed	HH compliance	Unclear number of observations given; HH attempts improved significantly after intervention and remained improved after 1-month follow-up; Oncology: 11%->36% ($p<.001$), GI: 21%->54% ($p<.001$)	Possibility of Hawthorne effect; observations weren't tagged with HCW's identities; possible that staff with excellent HH habits were observed with greater frequency than those with poor habits, thus skewing the data and the statistical analysis.

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Lehotsky et al. 2015 Hungary	To improve the quality of HCWs HH technique through personalized, objective feedback using the innovative Hand-in-Scan device	Hand-in-Scan device: hands picture and use of UV-light→ instant visual feedback	113 HCWs; 9 wards in 3 hospitals	Quantitative; Single-component; The Hand-in-Scan device was used to monitor hand coverage. Digital images of both sides of the hands under UV-A light. Areas treated properly with the Optik solution showed brighter under UV light, while missed areas remained darker. Participants viewed the outcome of their performance on a screen: immediate feedback and explanation about mistakes in their HH technique.	Between October 2013 and August 2014; device used in each ward for 3 to 6 weeks de data collection	HH technique	Rate of inappropriate HH rubbing technique decreased by 35% (p<.001)	No control group; staff who were more highly motivated to improve their HH were more likely to return to the device to check their technique.
Macdonald et al. 2017 UK	To evaluate a prototype interactive tablet-based tool using visualisation techniques developed for in-service IPC training for hospital staff	Training tablet app using interactive visuals	Overall, 150 participants (all 3 stages); domestics, nurses, doctors, university nursing staff and other health-related staff; Various hospital and university settings;	Qualitative; Single-component; 3-stage process design; iterative co-development method. Stage 1-2: formative, interactive workshops→ to elicit detailed feedback; stage 3: evaluative→ to determine how well the training tool conveyed the key learning points.	Stage 1-2: 2-2.5 hours each; Stage 3 evaluation: 30-45 minutes; 3 stages over a 12-month period	IPC-related understanding and awareness	Evaluations of the tool re its relevance, clarity, appropriateness and helpfulness were very positive, with negative rating never exceeding 5 %	Convenience sampling of 3 main occupational groups→people with inherent interest in new learning opportunities→sample not statistically representative→limits generalisability of findings
Mackert et al. 2014 USA	To evaluate the potential of a health promotion campaign encouraging HH in a hospital setting	2 posters as part of a campaign	215 HCWs (those who evaluated the posters); various HCWs; A level 1 trauma facility	Quantitative; Single-component; posters were based on two concepts: Concept 1: promotion of HH at the facility, Concept 2: reminding providers that HH is not a new way to prevent the spread of infection and that they have it in their power to comply.	Poster campaign launched in March 2013; 5 months into the campaign→ staff encouraged to take a 94-item online survey to assess opinions	HH promotion	Concept 1 more effective than concept 2; for concept 1→ more likely to influence others' handwashing practices; the statistical significance varied across different aspects of posters	Online survey→ response bias; low response rate; survey data assessed intentions of behaviour→need for longitudinal and observational studies to establish the efficacy of these strategies; the 5 month period could have attenuated the campaign effects;
Morse et al. 2009 Australia	To determine the prevalence of recording the date and time of insertion of peripheral venous catheters (PVC)	Poster-based educational programme	HCWs; 300-bed teaching hospital	Quantitative; Single-component; 2-week poster-based educational programme; 10 days of data collection (for each patient the presence of a PVC along with date of insertion); then, 2 posters placed around; two week-after data were collected again for 10 non-consecutive days	Poster campaign lasted for 2 weeks	Recording of date-time of insertion of peripheral venous catheters	1109 contacts (571 before posters); No success of the programme	Posters alone fail to prompt clinicians sufficiently to influence behaviour→multimodal programme is more likely to be successful, especially if sustained and demonstrably supported by senior clinicians and hospital administrators.

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Nevo et al. 2010 USA	To assess the efficacy of various visual cues to improve HH compliance in a simulated patient environment.	Cues: dispenser in baseline location+flashing lights, dispenser in line of sight, dispenser in line of sight+flashing lights, warning sign	150 physicians and nurses; tertiary care teaching hospital	Quantitative; Multi-component; Simulation-based; quasi-experimental controlled study; use of dispenser in line-of-sight, flashing lights and warning sign	1-day study; one week after the completion of the study, participants were anonymously surveyed about HH	HH compliance	All cues increased the pre-examination HH compliance; warning sign was significantly more efficacious ($p<.001$) in improving HH compliance both before and after examination	Presence of measurement outliers; possible effect of confounding factor (ie, reading the sign before entering the room)
Pedersen et al. 2017 USA	To make progress in application of Universal Protocol, efficiency metrics and cleaning compliance	Remote video auditing: cameras with real-time auditing and results-sharing	Surgery department: 17-room operating room (OR) department	Quantitative; singe component feedback screens exhibited each room's performance on the patient safety triad, turnover times, and an overview of department performance, whereas the status screens outlined the activity in each room	Not clear how long it lasted	OR cleaning	Compliance with tasks in all three domains (patient safety, efficiency, and cleaning) monitored and measured with remote video auditing have greatly improved; compliance with the three components of the PST now ranges from 94% to 100% on a daily basis.	Costly technology; no statistical significance of results mentioned
Pope et al. 2014 USA	To discuss how one institution developed a simulation scenario to address the issue of isolation precautions and proper HH.	Simulation scenario experience including visualising the infection: use of gel and black light to make hand dirty areas visible	University students; University lab setting	Qualitative; Single-component; at the end of the simulation the lights went off and a black light used to create visualisation of the contaminated areas	Simulation took place in one day but not described; no mention to any follow-up	HH and isolation precautions	Feedback from students reflections; not clear how many students participated; positive feedback seem to come from one student and faculty members (but not clear how many)	Only info was from poststimulation reflective journals; faculty feedback conducted after all participants completed the simulation was available; only one institution with undergraduate nursing students;
Radhakrishna et al. 2015 India	To increase hand sanitizer usage among healthcare workers by developing and implementing a low-cost intervention using radio frequency identification and wireless mesh networks to provide real-time alarms for increasing HH compliance during opportune moments in an open layout ICU	Flashing lights	94 ICU staff (doctors, nurses, ancillary staff); 30-bed ICU	Quantitative; Single-component; quasi-experimental study; radio frequency identification cards and flashing lights around hand sanitisers→real time visual feedback to use it	November 2013-April 2014: observation for the intervention; a further 4 months of observation after uninstalling the intervention→to observe the sustainability of the effect	Hand sanitiser usage	A consistent increase in sanitizer use ($p<.005$) was observed in the intervention group both during and four subsequent months after the intervention	The system cannot accurately assign compliance when multiple individuals enter patient area; possibility to assign false misses; owing to the orientation of the motion sensor a HCW can go unnoticed;

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Sanchez-Carrrillo et al. 2016 Mexico	To evaluate HH compliance before-after video-assisted feedback sessions to the HCW in the haemodialysis unit and compare the results with a traditional direct observation method	Video-assisted feedback	HCW in a 13-bed haemodialysis unit	Quantitative; Single-component; prospective longitudinal intervention study; feedback to HCW using short videos of their own performance in the unit	5-month period; 1-month pre-intervention observations of HH compliance through video recording and direct observations ;2 feedback sessions took place (they don't say when)	HH compliance	5,402 HH opportunities; HH compliance for direct observation: 57%, 65%, 73% (pre-intervention, 1st intervention, 2nd intervention); video HH compliance: 21%, 34%, 50%; unclear effect as success varied across participants	Absence of long-term follow-up leaves the possibility for a low sustainability of the intervention; no impact on HAI in the unit
Sharma et al. 2015 India	To assess acceptability & tolerance of in-house prepared ABHR & to build capacity & confidence in HCWs Long term aim: to facilitate successful hospital-wide introduction of ABHR & to subsequently improve the HH compliance & effectiveness among HCW	Posters, finger tip culture and visual portrayal	183 HCWs assessed the ABHR (130 doctors); rural, tertiary care, teaching hospital (570 beds)	Quantitative; Multi-component; Acceptance-tolerability of ABHR, building confidence, handmade posters, reminders, supply of 'test product' at appropriate places; theory-based	9 sessions (25 to 45 minutes) were organized separately for doctors (6 sessions) and nurses (3 sessions) in March-May 2011.	Acceptance of 'test product'	83% doctors & 94% nurses were satisfied with the 'test product'. The confidence building activity was conducted with 116 participants; After single use of the 'test product', overall a significant reduction was observed for the CFUs on the blood agar plates (0.77 Log10, p <.001). A complete reduction (100%) in colony forming units on incubated blood agar plates was seen for 13% participants. 82% participants expressed their confidence in the 'test product'.	NO limitations discussed
Stewardson et al. 2014 Switzerland	To assess the efficacy of SureWash to improve HH technique amongst healthcare workers	SureWash educational tool: video measurement and instant feedback	63 HCWs in total; university hospital and a tertiary care hospital	Quantitative; Single-component controlled, before-after; 2 HCW groups; ''untreated-control group Design",	March to September 2013; t0, t1, t2	HH technique	No impact of the tool on the proportion of HCWs able to perform a complete HH action; but significant (median increase 2->3.8, p<.001) and durable impact on the number of poses performed correctly per HH action	Unable to track individual HCWs performance; no data regarding the importance of performing HH as per WHO recommendations provided

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Storey et al. 2014 UK	To establish accuracy and acceptability of an automatic contact monitoring system for HH.	Monitoring system with immediate visual feedback	67 participated (23 competed questionnaires); 96-bed acute cardiac hospital	Quantitative; Single-component intervention; a device generating a unique electronic signature placed in beds, table chairs; staff wore a modified identity badge (near-skin contact with the sensor); wi-fi system; a light in the badge changed colour (green, amber, red) according to detection of patient contact after touching the environment with (green) or without (red) HH. The default setting was amber, indicating that HH was required.	The study ran every day between 10:00h and 16:00h; no more info re the time scale of the study provided	HH compliance	Electronically monitored compliance rose three-fold and the significant improvement in Phase 2 was maintained in the subsequent two weeks when no feedback was given (Phase 3); There was a significant increase in compliance in the visually monitored audits, but less marked	No control group; The amber light should be abandoned as patients didn't understand its meaning
Wearn et al. 2015 New Zealand	To identify the effect of HH reminder signs on the use of antimicrobial hand gel and to reinforce HH educational messages that might assist in developing lifelong clinical habits.	Reminder signs	240 medical students in an undergraduate clinical skills center	Quantitative; single-component; Single-blinded, cluster RCT; 9 clinical skills student groups randomly assigned to intervention/control group; signs placed above every learning space	1 academic year; no follow-up	Hand gel use	Mean total use of hand gel per session was not significantly different between groups; No success	Students may reasonably perceive the setting as low risk and thus choose not to comply with HH; Soap and water hand-washing was not taken into account
Weggelaar-Jansen et al. 2016 Netherlands	To subconsciously influence HH behaviour	Screen savers with gain-framed messages	ICU of a medical centre; 27 HCWs eye-tracked	Quantitative; Single-component; Design study; HCWs eye-tracked to test visual attention to both gain-framed text and visual elements in screen savers visual attention: eye-tracking techniques. Peer pressure: questionnaire and observations.	Screen saver designs tested in 2 separate studies. No indication of duration of the study	HH behaviour	Fixation count showed that the subjects fixated significantly (p<.001); total fixation duration showed that most of the subjects fixated longer on the gain-framed text	Not clear what happens if the screen saver is abandoned and priming stops; design of the screensavers can be questioned; generalisability of findings

Study, country	Purpose	Type of visualisation	Population, setting	Study design, intervention	Duration	Outcomes	Findings	Authors' comments/limitations
Wiles et al. 2015 USA	To increase staff awareness about HH guidelines and improve HH compliance rates in the emergency department.	Use of uv light and microsphere powder, use of photographs of space and equipment	95 emergency nurses and technicians; 41-bed emergency department	Quantitative; mutlicomponent; Descriptive pretest-posttest QI project; experiential hand-washing learning activity and simulated infectious disease spread activity; HH knowledge using a 25-question online pretest; applied Glo Germ lotion in their hands; performed HH; UV light on the participants' hands, providing a visual representation of the effectiveness of their HH and the spread of the Glo Germ throughout the hand-washing area; next month meeting staff viewed presentation of spread of microsphere powder throughout the dep.; online posttest that was identical to the pretest	Post-test at 3-month follow-up	HH compliance	Increase in overall compliance; t(108)=-6.13, p<.04; 3 months follow-up: F(2,5)=9.89, p<.002	Convenience sample; unequal number of staff completed pretest and postest; findings cannot be generalised to other providers (limited sample)
Wyer et al. 2017 Australia	To investigate whether local complexity might be rendered tangible, discussable, and manageable, by involving local stakeholders in reflecting on footage portraying their care practices.	Video-reflexive ethnography	35 nurses (reflexive sessions); 66-bed, adult surgical unit	Qualitative; Single-component Post-qualitative research; theory-based; VRE carried out in 3 overlapping phases; the 1st two used video reflexive ethnography to elicit and explore patients' understandings, experiences, enactments of IPC; focus of current study is phase 3!: footage were presented to nursing staff during reflexive sessions	No indication of the phases' timeline	IPC-related perspectives and practices	Nurses were able to identify and negotiate not only the practical but also the relational complexities of patient involvement; nurses were able to consider broader issues around IPC and act on them.	None discussed; probably the presence of a control group within a mixed methods design
Yoon et al. 2016 USA	To evaluate ease of use and usefulness for nurses of visualizations of infectious disease transmission in a hospital.	Visualisations were based on actual infection data extracted from electronic health records: colour graphs and infographics	12 nurses/masters students; urban research-intensive nursing school	Mixed-methods; single-component; Observational study; convergent parallel; techniques: interview, think aloud, eye tracking; theory-based (Davis' Technology Acceptance Model); set of visualisations showed to participants in 3 repeating rounds: comprehension, comparison, reflection; user-centric design→ participatory approach	Each session: 20-30 min to complete; No follow-up	Ease of use and usefulness of visualisations of infectious disease transmission	Positive attitudes and immediate understanding of the visualisations can ultimately motivate them to be mindful of the need for prevention efforts; Statistically significant effect for intervention scenario 1 (use of line graph and infographic) (p=.04) and 2 (use of us of line graph and 2D and 3D infographics) (p=.01)	Limited generalisability; lab-based environment;

*Abbreviations are explained in the List of abbreviations page vii

4.4.2.2 Methodology and methods

The included studies were predominantly of quantitative methodologies (*n*=18) employing observations, survey tools, auditing and monitoring or measuring the use of products as data collection procedures. The remaining studies were of: qualitative methodology (*n*=3) expressed in interviews, questionnaires, workbook exercises with questions, think-aloud, simulation scenarios and participants verbal reflections, and mixed-methods studies (*n*=2) combining eye tracking techniques, survey tools, think-aloud, and interviews (table 4.2).

With regards to the study design, quantitative studies were quasi-experimental, before-after, cluster RCT, longitudinal and quality improvement. Qualitative studies were quality improvement and ethnographic-based and mixed-methods study designs were participatory (co-design) (table 4.2).

4.4.2.3 Study population

Not all of the included studies provided details about the sample size of the study participants with 1,688 participants reported across 15 out of the 23 included studies. The included studies reported on participants who were predominantly healthcare staff of various professions (predominantly nurses), and additionally 3 studies reported on recruiting student population (table 4.2).

4.4.2.4 Intervention settings

Participants were recruited from a range of healthcare settings including ICU, paediatric hospital, cardiac units, an oncology unit, a gastrointestinal unit, a trauma facility, an OR, a haemodialysis unit, an adult surgical unit and an emergency department. Seven studies recruited participants who were either students of health-allied disciplines or affiliated to an academic institution including teaching hospitals, a university lab setting and a university's clinical skills centre (table 4.2).

4.4.2.5 Study outcomes

Improving HH compliance, technique or related knowledge was the study outcome for the majority of the included studies (*n*=13), followed by promoting proper catheter use (*n*=2), increasing IPC understanding and knowledge (*n*=2) and determining the usage of hand sanitisers (*n*=2). Also, the included studies, reported on determining the head of the bed elevation (*n*=1), improving PPE behaviour (*n*=1), addressing isolation precautions (*n*=1), cleaning practices of the OR (*n*=1), determining the acceptance of a cleaning 'test product' (*n*=1) and evaluating the ease of use and usefulness of visualisations in relation to infectious disease transmission (*n*=1). As shown in table 4.2 more than one outcome measure was used in the studies by Assanasen, Edmond and Bearman (2008), Pope et al. (2014) and Radhakrishna et al. (2015).

4.4.2.6 Study quality

The specific tools used to appraise the quality of each study were agreed among the review team. More specifically, twenty studies were appraised using the QATSDD tool summarised in table 4.3. The remaining three studies were each appraised using the QI-MQCS tool (Appendix 6), CASP RCT checklist and CASP Qualitative checklist (Appendix 7) respectively.

For those studies which the review team used the QATSDD tool, each study's final score was converted to a percentage as was the case in IR1. The final rating system in 'Low', 'Moderate', 'Good' and 'High' was applied according to whether each paper's score fell into the following percentage ranges:

- Low: less than 25%
- Moderate: 25% to less than 50%
- Good: 50% to less than 75%
- High: 75% to 100%

For the remaining three studies where a final quality score was not able to be calculated as in the QATSDD tool, the reviewers mutually agreed to attribute the quality of papers using the aforementioned four percentages ranges considering the adequacy of the answered questions in the checklists. More specifically:

Quality Improvement study co-appraised using the QI-MQCS tool

- Wiles, Roberts and Schmidt 2015: Number of 'Met': 14/16 → 87,50%: High quality

  RCT study co-appraised using CASP RCT checklist

- Wearn, Bhoopatkar and Nakatsuji 2015:

  number of 'Yes': 4
  number of 'Can't tell': 4
  number of 'No': 1 → 44,44% (4 'yes' out of possible 9): Moderate quality

Qualitative study using CASP Qualitative checklist

- Wyer et al. 2017:

  number of 'Yes': 4
  number of 'Can't tell': 4
  number of 'No': 1 → 44,44% (4 'yes' out of possible 9): Moderate quality

As shown in Table 4.4 and considering the appraisal of the three studies not assessed using the QATSDD tool, the quality of studies overall was mixed. The majority of them were of moderate quality (*n*=14), followed by studies of good (*n*=4), low (*n*=3) and high quality (*n*=2).

The three qualitative studies (Pope et al. 2014; Macdonald et al. 2016; Wyer et al. 2015) were of good, moderate and low quality respectively with all three not providing adequate explanations and justifications about the format and content of data collection tools as well the selected analytical methods.

Although the two mixed-methods studies (Yoon et al. 2017; Beam et al. 2014) were generally well conducted and reported, they scored low in questions related to the sample representativeness and size, and the reliability and validity of the measurement tool that was used.

The remainder of quantitative studies were predominantly of moderate quality. The most common methodological issues that were identified related to the lack of an explicit theoretical framework in guiding the research, the sample size was not considered in terms of analysis, the selected method of data collection was not clearly justified and there was a lack of fit between the research questions and the methods of data analysis.

Table 4.3 Quality appraisal of studies using the QATSDD tool*

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Total score	%	Rating
Yoon et al. 2016	3	3	3	3	1	3	3	2	1	3	3	2	2	0	3	3	38/48	79,16	High
Stewardson et al. 2014	1	3	3	3	2	3	1	3	3	0	N/A	0	3	N/A	0	3	28/42	66,66	Good
Kukanich et al. 2013	0	2	2	0	1	3	1	1	2	3	N/A	2	1	N/A	3	3	24/42	57,14	Good
Weggelaar-Jansen et al. 2016	3	2	1	2	1	2	1	2	2	2	N/A	2	1	N/A	0	3	24/42	57,14	Good
Macdonald et al. 2017	1	1	3	1	2	2	2	2	N/A	N/A	0	0	2	2	3	2	23/42	54,76	Good
Nevo et al. 2010	3	2	3	1	1	1	1	2	0	1	N/A	3	1	N/A	0	2	21/42	50,00	Moderate
Radhakrishna et al. 2015	0	3	3	0	2	3	2	2	0	0	N/A	0	0	N/A	0	3	18/42	42,86	Moderate
Diegel-Vacek et al. 2016	3	3	2	3	1	3	0	0	0	0	N/A	0	1	N/A	0	1	17/42	40,48	Moderate
Sanchez-Carrillo et al. 2016	0	1	3	0	2	3	2	2	2	0	N/A	0	0	N/A	0	2	17/42	40,48	Moderate
Sharma et al. 2015	2	3	3	0	1	2	1	2	0	0	N/A	0	1	N/A	1	1	17/42	40,48	Moderate
Mackert et al. 2014	0	1	3	0	2	2	2	2	0	0	N/A	0	0	N/A	1	3	16/42	38,10	Moderate
Storey et al. 2014	0	3	3	0	1	3	2	2	0	0	N/A	0	0	N/A	1	1	16/42	38,10	Moderate
Beam et al. 2014	2	1	3	0	1	3	1	2	0	0	0	0	0	2	0	2	17/48	35,42	Moderate
Birnbach et al. 2016	1	2	1	2	1	2	0	0	0	0	N/A	0	1	N/A	2	2	14/42	33,33	Moderate
Lehotsky et al. 2015	0	1	2	0	1	3	1	1	1	0	N/A	0	3	N/A	0	1	14/42	33,33	Moderate
Assanasen et al. 2008	0	2	3	0	1	1	1	2	0	0	N/A	0	0	N/A	0	2	12/42	28,57	Moderate

Caniza et al. 2007	0	0	3	0	1	3	0	2	1	0	N/A	0	0	N/A	0	2	12/42	28,57	Moderate
Morse et al. 2009	0	1	3	0	0	3	1	0	0	0	N/A	0	1	N/A	0	0	9/42	21,43	Low
Pedersen et al. 2017	0	1	3	0	1	1	2	0	0	0	N/A	0	0	N/A	0	1	9/42	21,43	Low
Pope et al. 2014	0	1	2	0	0	1	0	0	N/A	N/A	0	0	0	0	0	1	5/42	11,90	Low

*Explanation of scoring key: 0=not at all, 1=very slightly, 2=moderately, 3=complete

4.4.3 Study characteristics reflecting the IR's research questions

4.4.3.1 What visualisation-centred interventions have been implemented?

A wide range of visualisations were reported in the identified studies. These visualisations comprised either static forms of visualisation (e.g. a poster or flipchart) (*n*=4) or dynamic forms of visualisation (*n*=10) (table 4.4). When the same or very similar visualisation was used in more than one study this counted as one visualisation form. The observable distinction between the two visualisation forms is that the dynamic visualisations required the active and immediate participation or engagement of participants in relation to the reported visualisation-centred intervention whereas the static ones did not. For example, the activation of flashing lights (here regarded as dynamic) in a clinical ward (e.g. Radhakrishna et al. 2015) indicated that healthcare staff had to wash their hands before they proceeded to patient care in order for the lights to stop flashing. Conversely, the use of posters as part of a HH campaign (e.g. Mackert et al. 2014) are regarded as a static form of visualisation as they merely provided information about HH without any condition for participants to apply the corresponding behaviour or engage with the intervention.

Table 4.4 Types of visualisation identified in IR2 with specific examples

Static	Dynamic
• colour posters • warning signs • screen savers with gain-framed messages • flipcharts	• video recordings of healthcare staff and provision of feedback • use of flashing lights • electronic devices providing visual feedback on hand washing technique and level of hands cleaning • a training tablet application using interactive visualisations • remote video auditing and provision of feedback • simulations using UV light to visualise dirty hands • use of finger tip culture and visual portrayal • implementation of monitoring systems with immediate visual feedback • use of UV light and microsphere and photographs of space and equipment to depict spread of pathogens • video reflexive ethnography as means to engage healthcare staff in reflecting on their own clinical practice

4.4.3.2 How are these interventions structured and applied?

To better reflect on the nature of this question, it is important to consider what the outcomes of each study were viz., what they aimed for achieving. As in the case of IR1, the outcomes of the included studies in the current review are seen as an interconnected spectrum of outcomes ranging from increasing understanding and knowledge regarding IPC to actual behaviour change as in the case of improving HH compliance.

Within this ambit, and during the selection process of the studies it became apparent that common characteristics were shared by groups of studies. This observation allowed for implementing the classification system as described in section 4.3.4.1 classifying studies as M1, M2, M3, M4 and C. That categorisation system further shaped the author's thinking and enhanced the final categorisation of the included studies in two distinct themes. The two themes refer to whether the identified studies aimed for the participants' conscious or subconscious engagement with the reported interventions, and whether the interventions were oriented primarily towards the individual/person or context/team level. These two themes are plotted in a template across two axes as shown in figure 4.2 below.

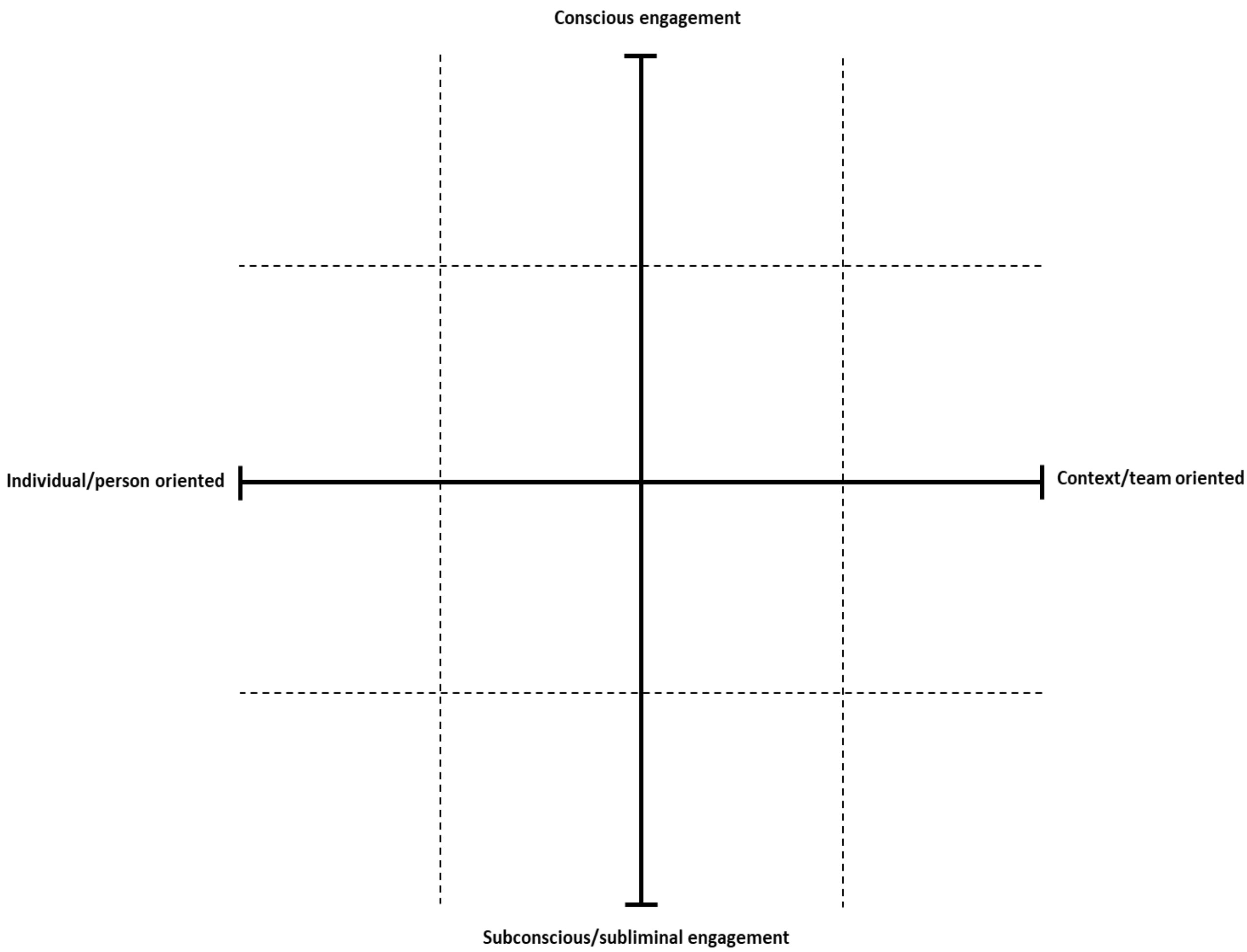

Figure 4.2 Plot of identified themes across two axes

Based on this template, the current author developed an indicative mapping of the 23 included studies across the four quadrants of the template. The mapping forms a relative positioning of the studies rather than a definitive one (figure 4.3). Nevertheless, the mapping is thought to provide an informative depiction of the studies' nature in relation to their structure and application of the reported intervention and may be seen as a useful representation of the concept of behaviour change in the IPC and HAIs context. Representative examples of studies from each of the four quadrants are provided at the end of this section.

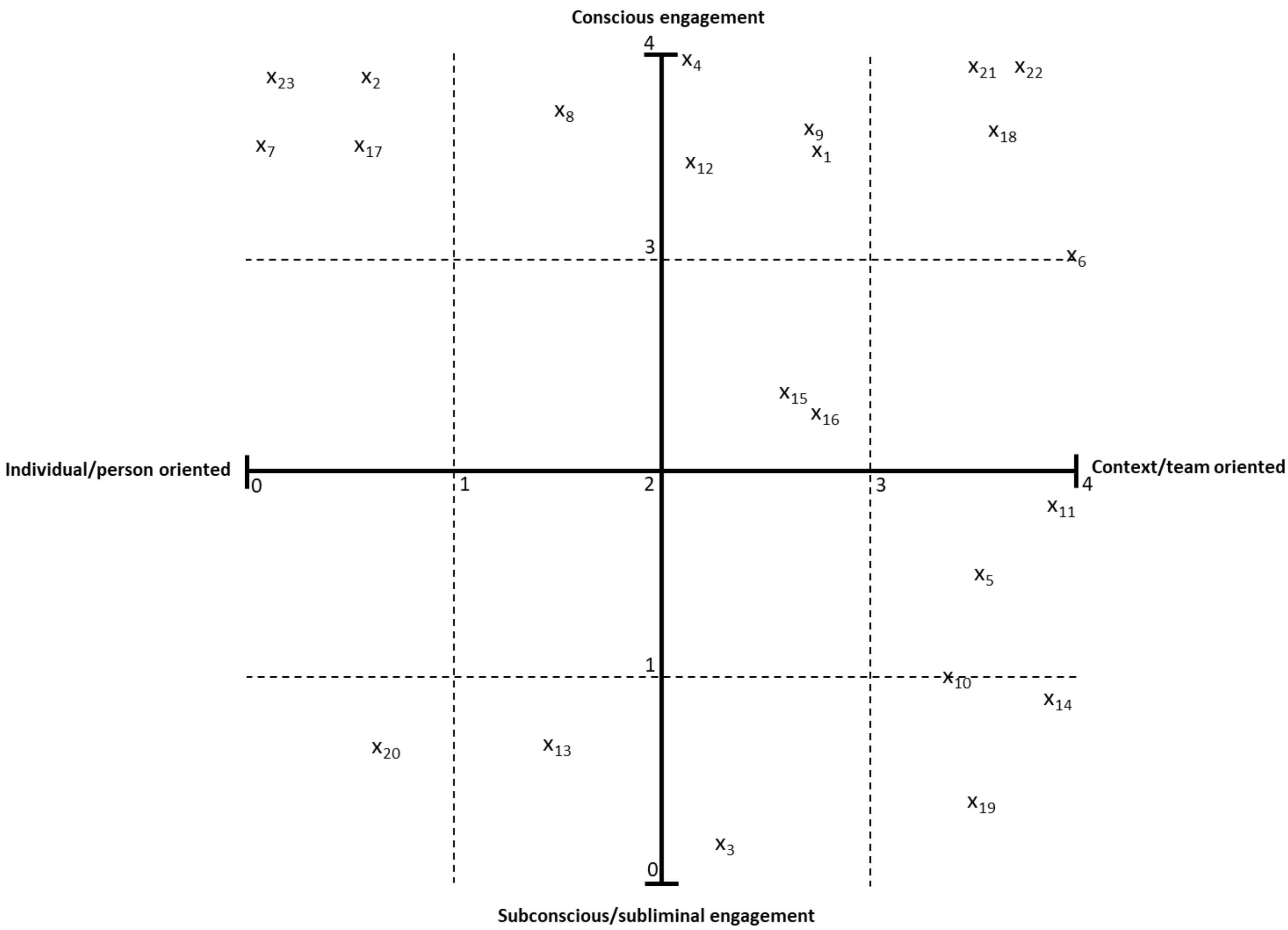

Figure 4.3 Mapping modes of orientation and engagement for the 23 visualisation-centred interventions

The above mapping was developed using a form with a '4-point ruler' where the relative position of each study was indicated for the horizontal and vertical axis (see Appendix 8). As a mapping exercise the current author (KT) and a member of the review team (CM) used this form to independently indicate the relative position of 10 of the included studies and solve any positioning disagreements. The positioning of the studies was determined after reading and apprehending each study and immersing to the nature of each of them thus allowing primarily to decide which quadrant they belong to and then attribute their relative position within the quadrant. The remaining studies' position were determined by the current author. Note that the numbering system used in the figure 4.3 (i.e., X_1, X_2, X_3… etc.) corresponds to the papers' alphabetical order (based on the first author's name).

As can be seen in figure 4.3 the top-right quadrant is the most populated quadrant with 10 studies whereas the bottom-left quadrant was the least populated quadrant with 2 studies. Overall the Figure shows that the majority of the included visualisation-centred interventions required the participants' conscious engagement with the interventions (i.e., top quadrants; *n*=18) with a particular focus on the context and team level (i.e., top-right quadrant; *n*=10).

Along with the above mapping, each of the 23 included studies were considered by the current author in the light of their outcomes and overarching aim. Towards this direction the change strategies proposed by Chin and Benne (1985) formed the basis for a more in depth understanding of the rationale behind the studies' structure and application. Chin and Benne (1985) proposed three strategies for effecting change in human systems namely, *Empirical-Rational* (people are rational beings and interested in positive changes), *Power-Coercion* (people are compliant and mandated to change by an external authority), and *Normative-Re-Educative* (people are social beings and engage in positive changes through participating in the cultural re-norming). A combination of these approaches to change were detected in some of the 23 included studies, whereas one approach only seemed to have informed others. The change approach or approaches which informed each study have been mutually agreed by two reviewers (KT, CM) using a '4-point ruler' as shown in figure 4.4 below. The decisions taken for the mapping of all included studies are included in Appendix 8. Examples of studies from each of the four quadrants are provided below with explicit reference to the specific visualisations used as well as the structure and application of the intervention.

ID	**Article**	**Quadrant**	**Axis**	**Main graph:** **Nature of intervention** (X: orientation, Y: engagement)	**Reviewers' classification on predominant change approach** (based on Chin and Benne, 1985) noting that there is often a mix, and some may not fit any exactly
			X Y	 	

Figure 4.4 Use of '4-point ruler' for mapping IR2 studies

More specifically, at the bottom-right quadrant Nevo et al. (2010) (shown as X_{11} in figure 4.3) used visual cues, flashing lights and a warning sign aiming to improve healthcare staff's HH across two hospital rooms (i.e., team/context level). In addition, the dominant approach to change guiding the study appears to be Power-Coercion. In total, 150 nurses and doctors were randomly assigned to one of five groups and were asked to perform a focused physical examination of a patient within a simulated scenario and were expected to maintain HH during the examination. Each group employed five visual cues: the alcohol-based hand rub (ABHR) was placed in its usual location (Baseline group), the ABHR was relocated to direct line of sight upon entering the room (Line-of-Sight group), flashing lights were affixed to the ABHR in its usual location (Baseline and Flicker group), the ABHR was relocated to the line of sight with flashing light affixed to it (Line-of-Sight and Flicker group) and a large warning sign was placed next to the door warning healthcare that the room was under surveillance and failure to adhere to HH would trigger an alarm (Warning Sign group). In order to avoid any bias regarding HH performance, participants were informed that the study focussed on room design and its effect on workflow (i.e., subconscious engagement). The study was based on simulated scenarios, with the participating healthcare staff prompted to perform as they would normally do in a real clinical situation. The simulated patient who was a 'masked' member of the research team observed participants regarding whether they performed HH before and after the examination.

In another study example, Wyer et al. (2017) is placed on the top-right quadrant (shown as X_{22} in figure 4.3) and seems to adopt a Normative-Re-Educative change approach. More specifically, the study focussed on the use of a novel application of video-reflexive ethnography involving the engagement of patients and clinicians (i.e., conscious engagement). This approach included participants reflecting on video footage of their own and their colleagues' practices in group reflexive sessions with nursing staff (i.e., team context) with a focus on analysis their IPC practices.

A third study example adopting an Empirical-Rational change approach is the study by Lehotsky et al. (2015) placed in the top-left quadrant (shown as X_7 in figure 4.3). The authors implemented a training device targeting HH technique providing real-time and personalised feedback (i.e., individual level). One hundred and thirty-six healthcare workers across three hospitals were asked to perform the HH technique using the Hand-in-Scan device which monitored hand coverage and provided digital images of the hand using UV-light (i.e., conscious engagement). The hand areas that were covered in ABHR as a result of properly using a sanitiser solution showed brighter under the UV-light. Participating healthcare staff thus had the opportunity to receive individualised and visual feedback of their HH technique on a screen and an explanation about their mistakes. The device was placed in the clinical wards for three to six weeks and participants could use it as many times as they wished allowing the research team to follow changes in their HH technique during that period.

A fourth study example that focussed on the subconscious engagement of individuals (i.e., bottom-left quadrant) was the study by Weggelaar-Jansen et al. (2016). The authors explained that the screen savers can serve as subconscious stimuli for healthcare staff at an individual level providing in this way a form of social priming. The study aimed to investigate how screen savers with gain-framed messages should be optimally designed towards positively influencing healthcare staff's HH behaviour. This included the screensaver's layout and colour as well as the position of text and images. As part of this exploration a set of propositions were developed (e.g. "Other nurses want me to adhere to HH standards and screen saver", "Physicians want me to adhere to HH standards", "We can see you, but you can't see germs. Therefore, disinfect your hands.") and incorporated in various screen savers of different visual style. This was followed by an eye-tracking study with 27 healthcare staff in order to determine which screen savers attracted more visual attention among participants.

Overall, the vast majority of the identified interventions were regarded as single component (*n*=18) with only 5 regarded as multi-component interventions as can be seen in table 4.2. Single-component interventions were those interventions which either employed a single visualisation component (e.g. a visual training tablet computer app in Macdonald et al. 2016) or more than one component which were essentially alterations of the same visualisation (e.g. various posters in Mackert et al. 2014). On the other hand, multi-component interventions employed multiple visualisations as in the case, for example, of Sharma et al. (2015) who employed hand-made poster and visual portrayal of fingertip culture.

Another finding that is tightly related to the structure and application of the identified interventions is the concept of provision of feedback to participants. More specifically, the provision of feedback to participants was of central and explicit focus in 8 of the included studies (Assanasen, Edmond and Bearman 2008; Caniza et al. 2017; Lehotsky et al. 2015; Pedersen et al. 2016; Radhakrishna et al. 2015; Sanchez-Carrillo et al. 2016; Stewardson et al. 2014; Storey et al. 2014) and was facilitated by the use of technology (e.g. remote video auditing). The following section will reflect on the effectiveness of the identified interventions.

4.4.3.3 To what extent are these interventions effective?

The effectiveness of the identified interventions was based on the reported findings in each study along with the study design, the authors' conclusions and study limitations. Table 4.2 shows the primary study outcomes for all 23 identified studies and provides an indication on whether intervention effectiveness and sustainability has been achieved.

As shown in table 4.5 the success of the reported visualisation-centred interventions varied as indicated by the green, orange and red colours used. The majority of the reported interventions (*n*=14) were successful. This was determined if statistically significant results were provided for quantitative and mixed-methods studies where appropriate and if direct positive feedback by participants was given in relation to the implemented intervention in qualitative studies. At a general level, there is no indication that single-component interventions were more effective than multi-component intervention and vice versa.

Six studies failed to provide clear evidence on the success of the reported intervention as depicted in orange colour. Finally, four interventions were ineffective (Assanasen, Edmond and Bearman 2008; Birnbach et al. 2016; Morse and Macdonald 2009; Wearn, Bhoopatkar and Nakatsuji 2015) as shown by the study findings. Note that the study by Assanasen, Edmond and Bearman (2008) indicated statistically significant effects on HH and head of the bed elevation (in green colour) but failed to do so on the use of catheter (i.e., proportion of femoral catheter to all central venous catheter-days) (red colour). What is interesting in these findings is that all these four ineffective interventions employed posters or poster-based visualisations (i.e. signs). This might imply that such visualisation approaches fail to bring about success in IPC practice and positively influence healthcare staff regarding HAI. In addition, apart from the study by Assanasen, Edmond and Bearman (2008), the remaining three studies were placed at the bottom-right quadrant as described in the previous section. This suggests a weak or no link between poster-based approaches and teams of healthcare staff that engage with poster-based approaches on a subconscious or subliminal level.

In terms of the sustainability of the intervention's effect, remarkably, only four studies explicitly referred to it (ranged from one to four months) and 3 of them reported a sustainable intervention effect that was statistically significant (table 4.5). The rest of the studies (n=19) either did not explore the concept of sustainability or did not provide clear and explicit information about it.

Justifications about the selection of the reported visualisations were not provided by the majority of the authors although some of them did explain their selections (e.g. Weggelaar-Jansen et al. 2016; Diegel-Vacek et al. 2016). This finding may suggest that such selections have been expedient although it is recognised that in depth explanations by the authors regarding their decisions is not always feasible owing to word limit constraints. If visualisations have been randomly selected and implemented indeed then this could partially explain why interventions have been either ineffective or unclear in terms of the intervention effect.

With regard to the study designs, a number of issues may have hindered the effectiveness of interventions and potentially limited the generalisability of the findings. For example, such issues are related to the absence of a control group (e.g. Assanasen, Edmond and Bearman 2008; Lehotsky et al. 2015; Storey et al. 2014), the use of small sample sizes (e.g. Beam et al. 2014; Pope et al. 2014) and the use of a convenience sample (e.g. Wiles, Roberts and Schmidt 2015). Authors, also, reported on the potential Hawthorne effect (i.e., the modification of the behaviour by people owing to their awareness of being observed) (Chen et al. 2015) that may have influenced participants' behaviour owning to the observational nature of the study (e.g. Birnbach et al. 2016; Diegel-Vacek et al. 2016; Kukanich et al. 2013; Yoon et al. 2016). Low response rates in surveys (e.g. Mackert et al. 2014; Assanasen, Edmond and Bearman 2008) as well as reliability and accuracy issues related to the testing instrument have been reported as well (e.g. Caniza et al. 2007; Radhakrishna et al. 2015; Weggelaar-Jansen et al. 2016).

Looking closer at the mapping of studies across the four quadrants and whether they have been effective it is suggested that visualisation-centred interventions that are targeted at the person/individual level and involve the participants' conscious engagement (i.e., top-left quadrant) may be more effective (as all studies were effective apart from one which resulted in unclear conclusions) followed by visualisation-centred interventions that engage wider teams at a conscious level (i.e., top-right quadrant where more variation on effectiveness is present). The limited number of visualisation-centred interventions placed at the bottom-left quadrant (n=2) which are targeted at the subconscious/subliminal engagement of individuals does not allow for fruitful insights to be drawn. The reported approaches in those two studies involved use of gel and black light to make hand dirty areas visible as part of a simulation learning experience (Pope et al. 2014) and use of social priming as part of screen savers with gain-framed messages (Weggelaar-Jansen et al. 2016) may form the basis for further research in this area.

Table 4.5 Success of reported visualisation-centred interventions on primary outcomes and sustainability of effect (table continues on next page) *abbreviations of outcomes and colours used are explained at the end of the table.

Study	HH	HoB elevation	Catheter use	IPC	Hand sanitiser	PPE	IP	ORC	ABHR	AoV	**Sustainability**
					Type of outcome						
Assanasen et al. (2008)											Not explored
Beam et al. (2014)											Not explored
Birnbach et al. (2016)											N/A
Caniza et al. (2007)											Not explored
Diegel-Vacek et al. (2016)	†										Not explored
Kukanich et al. (2013)											Yes, at 1 month but not statistical signif.
Lehotsky et al. (2015)											Not explored
Macdonald et al. (2017)				†							Not explored
Mackert et al. (2014)											No
Morse et al. (2009)											N/A
Nevo et al. (2010)											Not explored
Pedersen et al. (2017)								†			Unclear

	Type of outcome										
Study	HH	HoB elevation	Catheter use	IPC	Hand sanitiser	PPE	IP	ORC	ABHR	AoV	**Sustainability**
Pope et al. (2014)											Not explored
Radhakrishna et al. (2015)											Yes, at 4 months
Sanchez-Carrillo et al. (2016)											Not explored
Sharma et al. (2015)											N/A
Stewardson et al. (2014)											Partially, at 3months
Storey et al. (2014)											Not explored
Wearn et al. (2015)											N/A
Weggelaar-Jansen et al. (2016)											No
Wiles et al. (2015)											Yes, at 3 months
Wyer et al. (2017)											Not explored
Yoon et al. (2016)											Not explored

***Green** colour denotes statistically significant success of the intervention in achieving the outcome, **Orange** colour denotes unclear effect of the intervention on the reported outcome and **Red** colour denotes the intervention has been unsuccessful. Explanation of abbreviations used: HH (Hand hygiene), HoB (head of bed), IPC (infection preventions and control), PPE (personal protective equipment), IP (isolation precautions), OR Cleaning (operating room cleaning), ABHR (alcohol based hand rub), AoV (acceptance of visualisation) †denotes statistics not provided.

4.5 Discussion

4.5.1 Key findings

This IR was undertaken to explore the nature and scope and effectiveness of visualisations used in HAIs-related interventions as well as the wider context within which they have been implemented.

Although a high level of heterogeneity of interventions was observed (e.g. in terms of range of visualisations, study designs, study outcomes), it was possible to identify four categories of visualisation-centred interventions that included: context/team oriented interventions involving the conscious engagement of participants (*n*=10), individual/person oriented interventions involving the conscious engagement of participants (*n*=5), individual/person oriented interventions involving the subconscious/subliminal engagement of participants (*n*=2) and context/team oriented interventions involving the subconscious/subliminal engagement of participants (*n*=6).

Within the four categories, further observations were drawn regarding the type of visualisations and interventions. More specifically, the identified visualisations were predominantly dynamic (*n*=10) and less so static (*n*=4). The limited or even no effectiveness of the latter, which were primarily poster-based visualisations, renders their effectiveness into question. The active types of visualisations were more effective especially those that involved the provision of feedback to participants in relation to their IPC-related performance. These findings are in concordance with Engelen et al. (2018) who questioned the effectiveness of posters. They suggested that using posters in health promotion appears to be "a thing of the past" and called for developing interventions characterised by novelty and interactive methods.

In addition, static and active visualisation types were part of overarching intervention categories based on the number of components. More specifically, single-component interventions were supported by the vast majority of the included studies (*n*=18), with only five studies regarded as multi-component. Despite the predominance of the former, there was an inherent variation in terms of effectiveness thus providing no indication or any indicative pattern that they may be more effective than multi-component interventions. On the other hand, all five multi-component interventions (Wiles, Roberts and Schmidt 2015; Sharma et al. 2015; Nevo et al. 2010; Kukanich et al. 2013; Assanasen, Edmond and Bearman 2008) were found to be effective. Interestingly, two out of a total four studies which explored the concept of intervention sustainability were multi-component. These findings cumulatively suggest, on one hand, that multi-component interventions may form the basis for effective and sustainable interventional solutions and, on the other, underscore the necessity to develop and implement more multi-component interventions to establish firm conclusions. This is not to argue that single-component interventions are not or cannot be effective nor that multi-component interventions will necessarily result in positive and sustained outcomes. It indicates, however, that the combination of more than one visualisation components within interventions appears to be more effective. A systematic review by Davis et al. (2015b) explored the effectiveness of strategies aimed at increasing patient involvement reminding healthcare staff about their HH. The authors distinguished strategies into single-component and multi-component but did not make any explicit reference as to which type of strategy may be more promising in terms of effectiveness.

With regard to study quality, the review describes an absence of high-quality studies with only two being appraised as high quality. Of them one was strong, in conventional terms, regarding its study design (i.e., RCT) (Wearn, Bhoopatkar and Nakatsuji 2015). Furthermore, many studies exhibited major issues related to the sample representativeness and size as well as the justification of data collection and analysis methods. This finding indicates that studies need to be designed and reported in a more rigorous way to allow for replication in the same or different contexts.

Despite the fact that the concepts of culture and social context were not the focus of this IR, it was evident that the majority of studies were conducted in high-income countries (WHO 2011). The fact that only five studies were conducted in middle income countries (one in Mexico and one in Thailand) and low-income countries (two in India and one in El Salvador) (WHO 2011) highlights the dearth of evidence from these societies. An implication of this is that conducting research in high-income countries alone will not aid in improving IPC and reducing HAIs at a global level. Therefore, fostering and capitalising on research across middle-, and low-income countries as well will help to better understand how visualisation-centred interventions may be implemented leading to successful and sustainable effects. As an example, the interventions reported by Sharma et al. (2015) and Radhakrishna et al. (2015) (both from India) utilised various simple, effective and low-cost visualisations to positively impact on healthcare staff (e.g. handmade posters, flashing lights), interventions that can be replicated successfully in similar contexts across higher and lower income countries.

4.5.2 Strengths and weaknesses of the IR

The strengths of this integrative review are that it was conducted in a systematic and rigorous way and that to the author's knowledge it is the first review exploring and elucidating such a wide field. More specifically the included studies were of various methodologies and a wide range of nature and scope. Overall, this IR suggests that the use of visualisations has the potential to positively influence healthcare staff in their IPC practices. The identification of pertinent interventions implemented among both healthcare staff and student populations highlights that the current findings may be useful for guiding clinical practice and informing academic curricula through education and training.

The fact that the studies were published within the last decade could be regarded as a weakness. However, this decision was dictated by preliminary scoping exercises indicating an unmanageable number of studies of potentially no relevance to the nature of this IR. In addition, the inclusion of studies which were predominantly of moderate quality may only allow findings to be generalisable across similar contexts.

4.5.3 Reflections and future direction

Based on the findings of the review, an indicative combination of elements may guide the development of effective and sustainable visualisation-centred interventions. More specifically, multi-component interventions appear to prevail over single-component interventions. Thus, the former could target the engagement of individuals at a conscious level, while making use of active forms of visualisations and provide feedback to participants about their performance in relation to IPC (figure 4.5).

Figure 4.5 Elements that may form an effective and sustainable visualisation-centred intervention based on the findings of IR2

Taking the above into consideration, there is evidence that visualisation-centred interventions can positively influence healthcare staff towards improving IPC practice. However, findings must be interpreted with caution especially regarding the degree to which interventions are effective and whether positive outcomes are sustained over time.

Despite that the authors of the included studies acknowledged various limitations that may explain why some interventions have been unsuccessful, other questions give rise and necessitate explicit justifications. These questions, for example, refer to:

- *Why were the chosen visualisations favoured compared to others?*
- *Why were the particular intervention structure and content selected?*
- *How can interventions be improved in terms of effectiveness leading to sustainable effects?*

These questions along with a similar set of questions raised and presented in IR1 are generally not found in the papers suggesting that further research is required to establish these gaps. Therefore, these questions formed the basis for asking them directly to individuals with expertise in the field. The next Chapter consequently describes a Delphi study conducted as being directly informed by the findings of the two IR.

4.6 Conclusion

In conclusion, despite the fact this IR aimed to map such a wide and previously unexplored field it has made a major contribution to depicting the state of current evidence in relation to visualisation-centred interventions in IPC and HAIs field. Findings provide specific insights as to the usefulness and ultimately effectiveness of visualisation-centred interventions that aim to positively influence healthcare staff in the field of IPC and HAIs. Although further research is required to delineate important research questions, this IR provides direction to researchers and contributes to better shaping the development of visualisation-centred interventions in the field.

Chapter 5

Delphi Study

Chapter 5

TOWARDS CONSENSUS IN THE DEVELOPMENT OF BEHAVIOUR CHANGE INTERVENTIONS THAT BEST COMBINE THEORY AND VISUALISATION IN THE HEALTHCARE-ASSOCIATED INFECTIONS FIELD: AN E-DELPHI STUDY

5.1. Introduction to the Chapter

This Chapter presents the findings of a Delphi study which is directly linked to the previously conducted IRs as part of this doctoral research. More specifically the Chapter provides a detailed account of applying the Delphi method (also referred to as Delphi technique) towards achieving consensus in the development of behaviour change interventions that best combine theory and visualisation in the HAIs field. A number of core methodological concepts regarding the current Delphi study will be detailed and findings will be presented and discussed in light of pertinent studies and implications for further research. Findings of the Delphi study have also informed the next and final Phase 3 of this research involving focus group discussions with nurses and infection control staff (see Chapter 6).

5.2 Background

As explained in Chapter 2, the overarching research methodology of this doctoral research is described as a sequential multi-method pragmatic inquiry with each one Phase linking to the next. In view of this sequential link, the findings from the two IRs (Phase 1) directly informed the conceptualisation and conduct of the Delphi study (Phase 2). The latter is, thus, seen as a natural progression of the two IRs following analysis and overall consideration of Phase 1 findings. In the following sections the rationale for selecting the Delphi method is further explained, and the purpose of the current Delphi study is stated.

5.2.1 Rationale for using the Delphi method in the current study

The two IRs (Chapters 3 and 4) addressed gaps in the literature in that they shed light as to what theory-based, and visualisation-centred interventions there are, how they are applied, and which seem to work. However, there was very little clarity in relation to which parts work better than others within interventions and how and why parts or whole interventions work. From the two IRs it also appeared that theory and visualisation have not been yet extensively coupled nor has their selection been adequately justified whenever the two have been combined. More specifically, the two IRs did not determine one definitive theory (IR1) or visualisation (IR2) as being dominant in terms of frequency of use, provided low or no justification for the selection of theory and visualisation (in IR1 and IR2 respectively), identified a variety of designs the majority of which were not strong in conventional terms (e.g. before and after designs) and showed no long-term effectiveness in the developed interventions. These observations were key because a major reason for carrying out this doctoral research was to try to not only identify what theory-based and visualisation-centred interventions existed in this field, but to consider in more depth the following question:

> *What is a suitable and effective theoretical approach for designing a visualisation-centred intervention to aid healthcare staff prevent and control HAIs?*

The above findings as part of the two IRs synthesis suggested that further gaps in knowledge existed and consequently led to the creation of a new research agenda (Torraco 2005) which laid the foundation for the current Delphi study. This agenda flowed logically from the critical analysis of the IRs and posed a set of provocative questions which reflected the current researcher's personal interest in the topic. For example, 'why did the included interventions use theory and/or visualisation and what were they aiming to achieve through this?', 'how effective did the authors of the included studies perceive that the theory and/or visualisation contribution were and what were the criteria for these particular selections?' and 'what implications or recommendations can arise for the design, developing, testing, implementation, evaluation and sustainability of these interventions for IPC-, and HAIs-related research?'

The aforementioned observations and questions that were posed were central to the impetus to conduct a Delphi study. In addition, as the doctoral research was progressing, and the researcher's thinking was expanding at the time new ideas and concepts fed in providing new perspectives of investigation. One of these was the concept of behaviour change techniques (BCTs).

A BCT is thought to be the 'active ingredient' of behaviour change interventions and is a distinct and integral component which is designed in order to influence behaviour (Michie et al. 2013). According to the Behaviour Change Wheel developed by Michie et al. (2014) designers of behaviour change interventions need to understand the behaviour, identify intervention options and determine the content and implementation options. Within these three tasks, the theoretical underpinnings of the intervention, the mode of delivery (i.e., how the intervention is delivered) and the BCTs may be seen as influential towards impacting on behaviour (Michie et al. 2018; Atkins and Michie 2015; Webb et al. 2010).

Although, the aforementioned three concepts were not the explicit focus of this doctoral research at the conceptualisation of the thesis, it later became apparent that IR1 and IR2 reflected directly on the first two of these concepts namely, theoretical underpinnings of the intervention (as this was the central focus of IR1) and mode of delivery (as IR2 focussed on visualisation in interventions as a means of intervention delivery), respectively. Considering that this triad of concepts has a potential role to play in the success of pertinent behaviour change interventions it was envisaged that the explicit incorporation of BCTs in the Delphi study along with the concepts of theory and visualisation would provide additional and helpful insights in the study.

The Delphi method is an iterative and sequential multi-stage process that provides a pragmatic and anonymous process for consensus (Brett et al. 2017). It was deemed as the most appropriate method for addressing the aforementioned issues based on the following reasons: the posed research questions following analysis of Phase 1 would benefit from key experts' subjective opinions on a collective basis; the diversity of participating key experts (in terms of academic and professional backgrounds) was intended at the planning stage of the study as this would allow for fruitful insights from different perspectives to emerge; the online form of the study would allow for recruiting geographically dispersed key experts; group conflict and individuals dominating over others would be reduced (if not totally disappeared) as this Delphi study was online and thus did not require key experts to meet face-to-face.

Taking the above into consideration, 6 open-ended questions were developed and presented to participating key experts in round 1 of the Delphi study (these questions are described in section 5.4.8). The decision to have a qualitative first round was taken in order to elicit expert opinion. This consequently led to the development of pertinent statements which participants were asked to rate in rounds 2 and 3. The fine details of the structure and content of all three rounds are presented in section 5.4. To the current author's best knowledge, no previous Delphi or similar consensus-based study has investigated the concepts of theory and visualisation in the field of IPC and HAI by seeking and harnessing expert opinion.

5.2.2 Delphi study aim and research questions

Of the three most common consensus-based approaches as described presented in Chapter 2, the Delphi method was deemed as most appropriate and was thus applied in this research due to the advantages outlined. Thus, eliciting experts' creative thinking about potentially successful theory-visualisation dyads would helpfully inform the evidence base in this field.

More specifically, this Delphi study sought to answer the following overarching questions:

1. What types of theory and visualisation can optimally be combined and best inform the development of pertinent interventions in the field of HAIs and IPC by harnessing expert knowledge?

   Consequently, sub-questions to be addressed were:

   - What behaviour change techniques can best facilitate the delivery of such interventions according to the experts' opinion?
   - How can the long-term effectiveness of such interventions be sustained according to the experts' opinion?

2. What consensus can be achieved (if at all) among participating experts regarding their responses to the above questions?

5.3 Method of the current Delphi study

The following sub-sections outline the decisions taken regarding the development and pilot-testing of round 1 questionnaire, the selection of key experts and the recruitment process, the level of consensus applied, and the structure and content of rounds 2 and 3. The specific steps taken to promote quality in the study as well as aspects of research governance are discussed.

5.3.1 Conceptualisation and pilot-test of round 1 questionnaire

It is common for Delphi studies to have a first quantitative round comprised of statements where participants are asked to provide a rating using a Likert scale (e.g., Monterosso, Ross-Adjie and Keeney 2015; Eubank et al. 2016). This is quite often achieved through analysis of previously conducted research usually though systematic literature reviews, focus group discussions, or interviews and this pertains to a modified Delphi study (Albarqouni et al. 2018; Stewart et al. 2017). The current Delphi study, though, applied the classical structure of the method with a qualitative first round and the reason for this is explained below.

Although the two IRs in Phase 1 revealed a range of theories and visualisations, these were not a complete taxonomy and it was decided that open-ended questions would elicit more nuanced expert opinion and thus be more beneficial in the development of the subsequent round 2 statements. This was a unique chance here to first elicit expert opinion, and then consider it alongside the IRs findings.

Following analysis of the IRs in Phase 1 and the identified knowledge gaps, open-ended questions were developed by the PhD candidate. Numerous drafts of these open-ended questions were produced and reviewed by and discussed with members of the supervisory team. These questions were then pilot-tested among academic colleagues from the extended research network of the current researcher. More specifically, academic researchers with a range of expertise and interest in the wider concept of IPC and HAIs were initially invited to provide their feedback on these questions. These researchers were AHRC-funded principal investigators and co-investigators (in total six researchers participated in the pilot-test) of projects related to the concept of visualisation in the IPC and AMR context. The questionnaire was sent to them including background information about the study and how this links to the doctoral research.

The pilot-test of the questionnaire provided helpful insights resulting in a number of actions to be taken in order to enhance the utility of the formal questionnaire to be presented in round 1. More specifically, the feedback indicated that the study as a whole, and the Delphi study in particular, are necessary, innovative and ambitious. Also, the overall validity of what was proposed was not questioned. In addition, the content of the questionnaire and the rationale of the study was clearly understood especially by the IPC and theory researchers who participated in the pilot testing of the questionnaire. Notwithstanding, there was some difficulty in conceptualising and answering some of these questions by 2 AHRC grant-holders with a background in Arts and Humanities. This did not suggest that key experts from these disciplines were not considered for inclusion in the study nor that they could not provide insightful feedback. It highlighted, though, that there might not be a plethora of key experts with an explicit interest and experience in all three concepts of this study (i.e., theory, visualisation and IPC). The feedback, also, suggested that the indicative time for completing the questionnaire (i.e., approximately 20 minutes) was adequate.

The feedback from the pilot-test suggested a list of actions to be taken in order to improve the clarity of what was presented. One of the key actions to be taken was that brief and lay-friendly definitions of each of the major concepts under exploration needed to be provided at the very beginning of the questionnaire. This would allow the panellists who may not have in depth knowledge of all these concepts to better contextualise the questions and thus provide more insightful responses. It was, also, suggested that specific examples of theory-based and visualisation-centred interventions should be provided. Such examples could be linked to the findings of the two IRs and be mentioned at the beginning of round 1. Furthermore, it was important that the round 1 questionnaire should mention that a wide view of theory was taken in the Delphi study spanning from models and frameworks. Finally, there were responses in the pilot-test pertaining to different questions that were based on the idea that "it all depends on the context, target group and what you are trying to achieve". To minimise the number of such potential responses it was decided to remind experts of the context and target population in a separate statement at the beginning of the questionnaire. The above actions aimed to provide clarity and simplification across the questionnaire. The pilot-test of the questionnaire was conducted in December 2017.

5.3.2 Panel of key experts

The selection of the key experts, including their background and the size of the panel, is a key part of the Delphi method and has received some debate in the literature (Boulkedid et al. 2011). Hsu and Sanford (2007) discuss the proposition stated by Delbecq, van de Ven and Gustafson (1975) according to whom individuals for a Delphi study must be well qualified and are recommended to be top management decision makers, professional staff members and respondents whose judgements are being sought. Elwyn et al. (2006) suggested four types of stakeholders suitable for a Delphi study namely patients, health practitioners, policy makers, and decision aid developers and researchers. These assertions highlight the need for selecting people who are knowledgeable of the topic under investigation and come from multidisciplinary backgrounds. According to Bishop et al. (2016) the key experts of a Delphi study should be committed to the proposed study, are credible and their backgrounds are heterogeneous enough so that to represent a range of related stakeholders.

Taking into account the importance of carefully selecting key experts, 3 specific selection criteria were developed and applied in the current study. These criteria were based on the premise that potential experts must be knowledgeable and skilled in providing their insights to the questionnaire. This purposive sampling was envisaged to be formed by any individual with relevant knowledge and experience in healthcare or behaviour change-related research involving theory and/or visualisation.

Potential panel experts needed to meet the following 3 inclusion criteria:

Criterion 1: a principal or second author of any of the key papers (final selection) in IR1, IR2 or similar research papers from the general literature search. They were likely to be highly knowledgeable of the questions that emerged from the two IRs which formed the basis for conducting the Delphi study.

or

Criterion 2: a principal or second author of any relevant published abstracts from leading national and international IPC conferences from 2015-2017. Their research was expected to be closely related to the nature of the questions which the current Delphi study aimed to answer. A three-year time frame was set to focus on the most recent abstracts published in IPC-related conferences.

or

Criterion 3: a core member of the AHRC-funded HAIVAIRN network who has published relevant research in the field. These experts were likely to be highly knowledgeable on, and interested in concepts related to IPC, HAIs and visualisation and less so explicitly in concepts related to behavioural theory. However, this was not regarded as being problematic because HAIVAIRN members covered a wide range of disciplines and backgrounds thus strengthening heterogeneity and multidisciplinary in the study.

The panel was expected to be heterogeneous and multidisciplinary as key experts were more likely to be academics, researchers and clinically situated people with senior roles (e.g. infection control nurses, infection unit consultants). This was key in ensuring the overall study quality (Powell 2003). As regards the academic and research background of potential key experts it was envisaged that a range of disciplines would be identified including for example nursing, medicine, microbiology, psychology, sociology, arts and humanities. Chain referral, where the initially identified experts proposed the names of other potentially suitable colleagues, was also utilised in order to recruit other key experts for taking part in the study (Creswell 2013b).

Apart from the composition of the panel of key experts and the development and application of inclusion criteria, the size of the panel required in depth consideration. As Thangaratinam and Redman (2005) highlight, there are no hard and fast rules in relation to the size of a Delphi panel and neither has there been definitive determination of what comprises a small or large panel of key experts (Avella 2016). According to Linstone (1975) a minimum panel size of seven key experts is required whereas Akins, Tolson and Cole (2005) state that most Delphi studies' panels can vary in size from 4 to 4000 participating experts (Campbell and Cantrill 2001). Akins, Tolson and Cole (2005) in their study about healthcare quality and safety implemented the bootstrap sampling technique to determine the stability of responses and identified that a sample size of 23 key experts resulted in stable responses. Owing to the absence of firm guidance as to what panel size is most appropriate for a Delphi study design and based on pertinent Delphi studies (Page et al. 2015; Helmy et al. 2017) as well as experienced colleagues' recommendations, a minimum of 20 experts was intended to be recruited. The decision to have a fluid upper level was based on previous evidence suggesting that the reliability of the study increases with the panel size (Powell 2003; Akins, Tolson and Cole 2005).

5.3.3 Recruitment of key experts

Following identification of potential key experts based on their fit to the aforementioned three inclusion criteria, invitation e-mails were sent to them in December 2017 and January 2018 (Appendix 9). Potential key experts were contacted via their e-mails which were available in the public domain. They were asked to consider the invitation and respond as soon as possible indicating whether they wish to take part in the study. A reminder e-mail was sent out to those individuals who did not reply to the initial invitation e-mail two weeks later. No further communication was made for non-respondents. The academic colleagues who participated in the pilot-test of the questionnaire were not considered for the main Delphi study. Moreover, through the guidance of the PhD student's supervisory team, it was decided not to include three potential expert participants as it was envisaged that a small pool of potential examiners for the thesis would be required.

In total, 85 potential key experts were identified and contacted. The decision to approach a large number of potential experts was taken after considering that: the minimum intended sample size for this study was 20 individuals, potential key experts would most likely be extremely busy resulting in inability or unwillingness to participate thus potentially rejecting the study invitation (Birko Dove and Özdemir 2015) and participant attrition could be high as rounds progress (Hall et al. 2018). If the minimum sample size was not reached following initial invitation, more potential experts would be identified and contacted. However, this was not the case as 34 (out of 85 in total) initially accepted to take part in the study.

Table 5.1 presents the identified potential key experts based on the three inclusion criteria and peer reference and the number of them who accepted the invitation to participate in the study. Of the remaining 51 potential key experts, either no response was received (*n*=37), or the invitation was not accepted due to time constraints and other commitments (*n*=12). Finally, two (*n*=2) of them did not consider themselves as being key experts in the proposed topic.

Table 5.1 key experts who were invited and accepted to take part in the Delphi study

Source of inclusion	Number of key experts identified and invited	Key experts who accepted invitation
Criterion 1	56	20
Criterion 2	13	6
Criterion 3	9	4
Peer reference	7	4
Total	85	34

5.3.4 Consensus level and Likert scale

The level of consensus is another key aspect of the Delphi method that lacks explicit guidance (Sandrey and Bulger 2008). The most common way to express consensus is by setting a percentage level (Powell 2003). Adhering to the approach taken by other pertinent studies as well as consulting academic colleagues with relevant expertise from the researcher's academic institution, the consensus level in the current Delphi study was set at ≥70% using a 5-point Likert scale (i.e., 1=strongly disagree, to 5=strongly agree) (Silva, da Silva and Barreto 2018; Austin 1997; Keeney, McKenna and Hasson 2010). More specifically, consensus was achieved if ≥70% of key experts strongly disagreed/disagreed or agreed/strongly agreed with a particular statement in Rounds 2 and 3. In addition, a 5-point Likert scale was preferred over other commonly used Likert scales such as 7-point or 11-point scales as the former (i.e., 5-point) has been linked with better quality (expressed in quality coefficients) of the gathered data and lower misresponse to reversed items (Revilla, Saris and Krosnick 2013; Weijters, Cabooter and Schillewaert 2010).

The adopted 5-point Likert scale, also, allowed participants to give a neutral response (i.e., 3=no opinion) whereas a smaller scale (e.g. 4-point) would not give this option. This was important as, due to the heterogeneity of the theories, visualisations and BCTs, participants could not be expected to provide expert opinion on every single aspect. Another aspect of the Likert scale which is fundamental relates to its direction. More specifically, the decision to start with negative words in the scale (i.e., 1=strongly disagree) was based primarily on previous pertinent studies as mentioned above. This decision was, also, corroborated by research evidence suggesting a left-side bias (Holmes 1974). According to this bias, respondents tend to choose the options which are on the left side of a scale, whereas the bias is more pronounced when positive statements are listed on the left side of the scale (Friedman, Herskovitz and Pollack 1994; Chan 1991).

5.3.5 Response rate

Another key aspect of the Delphi method is the response rate between each round. It is suggested that the validity of the Delphi results can be affected by response rates (Gargon et al. 2019) as the ability to achieve optimal response rates can either safeguard or jeopardise the validity of the overall study (Hsu and Sanford 2007). Although response rates can vary from as low as 8% to as high as 100% (Keeney, McKenna and Hasson 2010), a minimum of 75% response rate is considered as optimal (Bowling 2014) and has been applied in the current study. In order to enhance the response rates in the current study specific measures were taken (Gerrish and Lacey 2010). More specifically, it was critical that potential key experts were interested in the topic. Although, this could not entirely be determined by the current researcher, the strict adherence to the inclusion criteria aimed to the identification of individuals who were both knowledgeable and interested in the study.

Key experts were, also, informed at the very early stages of the study (invitation e-mail) about the structure and content of the study as well as the time commitments required. Furthermore, in order to establish rapport with the participants all correspondence included a personalised salutation. The follow-up of non-respondents was also necessary. Participants were given two weeks to consider and complete the questionnaire with two reminder e-mails sent out after this period. When requested by the participants, extensions to complete the questionnaire were provided. Participants' contribution in the commencement of the field was appreciated and was communicated to all potential participant at the very outset of the study.

5.3.6 Iteration of rounds

The concept of iteration of rounds was, also, determined and specified at the conceptualisation of the study. This was a key consideration as the iterative and sequential nature of the rounds enhances the concurrent validity (Hasson, Keeney and McKenna 2000). The decision to include three rounds was based on published literature discussing the diminishing returns of including any more than three rounds (Skulmoski, Hartman and Krahn 2007). Also, the rationale for utilising the classic form of the Delphi method with a first qualitative round including open-ended questions was explained previously in section 5.4.1.

5.3.7 Controlled feedback

Providing controlled feedback is a core element of the Delphi method (Massaroli et al. 2017). The rationale for it is to inform the panel of all key experts' responses giving thus the opportunity for reflection and either retaining the initial rating or altering it. Controlled feedback in the current study was anonymous and provided in the third round in the form of descriptive statistics (distribution of panel's responses to statements in round 2 along with each key expert's individual rating) (Skulmoski, Hartman and Krahn 2007). This is further explained in section 5.4.10. The feedback provided in this study was collective as it emerged from the entire panel of key experts (Campbell et al. 2003).

5.3.8 Delphi round 1 questionnaire

Following the pilot-test of the questionnaire and based on the feedback received, it was decided that six open-ended questions accompanied by relevant background information and brief and lay-friendly definitions (where necessary) would form the round 1 questionnaire of the study. More specifically, key experts in round 1 were asked to provide their responses including explanations and examples to the following questions:

1. In your view, what theory(ies), framework(s) or model(s) can best inform interventions to help prevent and control healthcare-associated infections (HAIs)? Please give any explanations and examples of interventions and intended outcomes.

2. In your view, what types of visualisation can best inform interventions to help prevent and control HAIs? Please give any explanations and examples of interventions and intended outcomes.

3. In your view, which of the above theories and visualisations could best be combined for such interventions? Please give any explanations and examples of interventions and intended outcomes.

4. With reference to the 'Behaviour change techniques taxonomy' v1 below (Michie et al. 2013), type in the space below any behaviour change techniques (BCTs) that can best facilitate the delivery of such interventions? Can you, also, explain why?

5. How can the long-term effectiveness of such interventions be sustained? Please, give any examples and/or explanation.

6. What other recommendations would you suggest for the development of interventions combining theory and visualisation? Can you, also, explain why?

After liaising with the IT department of Robert Gordon University, the questionnaire was developed and presented in an online format using an in-house platform (https://www.rgu.ac.uk/delphi-behaviour-change-interventions).

5.3.8.1 Conduct of round 1

The 34 key experts who agreed to participate, were notified by e-mail about the commencement of round 1 providing a detailed participant information sheet (Appendix 10), and the URL directing them to the online questionnaire (Appendix 11). Participants were, also, provided with a consent form (Appendix 12) to indicate their agreement, sign it off and return an electronic copy to the current researcher. They were given two weeks deadline to provide their responses. An additional one week was given if participants required extension of the deadline or e-mail reminders had to be sent to non-respondents. In the questionnaire, key experts had to indicate their discipline and expertise as well as a unique identification number that was provided in the e-mail. The identification number would allow the identification of experts' responses by the researcher as the completion of the online questionnaire would result in anonymous submissions. The unique identification number allowed for anonymised responses. Round 1 commenced in late January 2018.

5.3.8.2 Analysis of round 1

Thematic analysis (Braun and Clarke 2006), as an accessible and theoretically flexible analytical process, was used. This process allowed for identifying, analysing and reporting themes and sub-themes within the data (Braun and Clarke 2006). The use of thematic analysis did not only aim to summarise the collected data, but importantly to interpret and make sense of it.

5.3.9 Delphi round 2 questionnaire

The second round was conducted in order to narrow down the focus of the study and start to reach a consensus. Due to the identification of technical issues with the online questionnaire (one participant reported 'saving' the form for later submission but responses were lost, and one participant reported submitting the form but no responses received by the researcher) and owing to the design complexity of the subsequent rounds, it was decided that rounds 2 and 3 to be designed using Microsoft Word by the current researcher.

The analysis of round 1 questionnaire yielded very rich and useful data which informed round 2 in general and specific ways. More specifically, the round 2 questionnaire comprised of 97 statements within four overarching areas namely, development of interventions, theories/frameworks/models, visualisation, and long-term effectiveness and sustainability (Appendix 13). Importantly, two intervention development scenarios were generated following round 1 analysis and key experts were asked to choose one and anchor their round 2 responses around the chosen scenario. The two scenarios were based on the two predominant types of interventions found within the two conducted IRs (phase 1 of current doctoral research) and round 1 responses: systems-wide, multi-modal interventions which seek to decrease HAI rates, and focal interventions targeted at increasing HH compliance. Based on them, the two scenarios were as follows:

Scenario 1: This scenario is targeted at developing systems-wide behaviour change interventions involving the whole healthcare institution, in this case a typical general hospital. Interventions in this scenario are targeted across the whole professional population of the institution aiming to decrease infection rates.

Scenario 2: This scenario is targeted at developing focal behaviour change interventions involving individual department(s) within the healthcare institution and/or small teams of healthcare staff. The department(s) and/or teams in this scenario would be part of a typical general hospital and interventions are aiming specifically to increase HH compliance among healthcare workers.

Types of theory and visualisation identified in the two IRs but not highlighted by key experts in round 1 questionnaire, were also included in round 2. Participants in this round were asked to rate each statement using a 5-point Likert scale; 5 – strongly agree, 4 – agree, 3 – no opinion, 2 – disagree, 1 – strongly disagree. Exception was the statements in part B of the questionnaire referring to theories, frameworks and models. Key experts in this section were required to indicate which of the them they were familiar with and among them to choose their 'top-2'. It was decided that this approach would be more meaningful for key experts as many of the statements in that section referred to specific theoretical approaches and a 1-5 Likert scale would not aptly reflect their opinion. This decision was taken after the pilot-test of the questionnaire. This suggested that that theory-related questions may require an in depth understanding and experience in applying the corresponding theoretical approach. The statements in this part were presented in three categories informed by Nilsen's (2015) classification of types of theories:

Category 1: Describing and/or guiding the process of translating research into practice

Category 2: Understanding and/or explaining what influences implementation outcomes

Category 3: Evaluating implementation

Key experts were prompted to provide their comments for specific statements or each part in general in separate text boxes at the end of each part. Round 2 commenced at the beginning of March 2018 with a two-week deadline for completion given. Extensions (one week) were provided to participants when requested.

5.3.9.1 Analysis of round 2 questionnaire

The statements which received a rating from 1-5 were analysed using descriptive statistics in the form of frequencies and percentages. This allowed to identify which statements reached a 70% consensus. Statements in part B were analysed in terms of which of them were indicated by the key experts as being familiar with. Those statements that were not indicated as such by any of the key experts were not presented in the next round. In addition, the 'top-2' selections that participants were asked to make across these statements were transformed into subsequent ratings (i.e., first option of 'top-2'=2 points, second option of 'top-2'=1 point). This allowed for the development of a list of statements in a descending order (i.e., highest rating to lowest rating).

5.3.10 Delphi round 3 questionnaire

The round 3 questionnaire commenced in mid-April 2018. Only those statements that did not reach consensus were included in round 3 questionnaire. For each of these statements, participants were reminded of their rating in round 2, as well as the distribution of ratings across the entire panel of key experts and were asked to indicate their rating (either to retain their previous one or alter it). The same rationale was followed in part B where the participants were reminded of their 'top-2' selection of theory-related statements and presented with the statements received the highest to lowest scores and were given the option to retain or alter their 'top-2' selection. Separate round 3 questionnaire were developed for each key expert presenting his/her round 2 responses and the panel's rating distribution. An example of round 3 questionnaire is found in Appendix 14. As in previous rounds, the deadline for completion was 2 weeks with a further 1-week extension to panel members requesting it.

The timeline of the current Delphi study from its commencement to its completion is shown in figure 5.1 below.

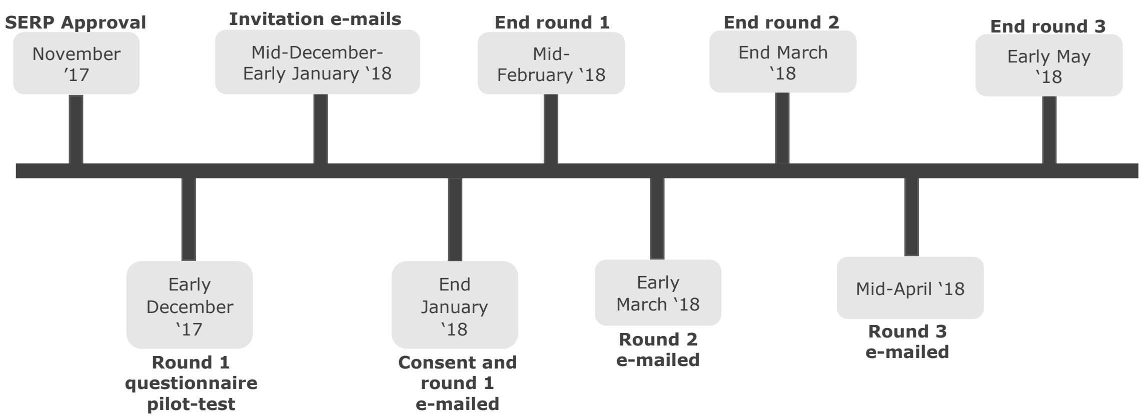

Figure 5.1 Timeline of the current Delphi study

5.3.11 Promoting quality in the current Delphi study

This section aims to highlight the most important choices and measures taken and mentioned above to ensure the Delphi study is sound in terms of methodological decisions. More specifically:

- A clear and robust decision trail was maintained throughout this research thus enhancing the credibility, reliability and validity of the study (Powell 2003).
- A pilot study of round 1 questionnaire was conducted to find out and resolve potential issues with the process of administering the questionnaire and

refine the questions if necessary. This is thought to have increased the content validity of the questionnaire and thus the robustness of the study overall (Clibbens, Walters and Baird 2012).

- A systematic selection of key experts based on inclusion criteria was performed leading to a highly heterogenous group (details are presented in section 5.5). This maximised the possibility for these individuals to be closely interested in the topic under investigation and thus participate in all three rounds of the study.
- Reminders and personalised e-mails were sent in an attempt to increase response rates. In this study, a minimum 75% response rate between rounds was intended to enhance the validity of the questionnaire and thus ensure the overall study quality.
- Feedback was provided to participants across sequential and iterative rounds. The selection of three rounds was determined at the conceptualisation of the study and was based on evidence about diminishing returns of including any more than three rounds (Skulmoski, Hartman and Krahn 2007).

5.3.12 Research governance

The current Delphi study was scrutinised and obtained ethical approval by the School of Nursing and Midwifery Ethics Panel (SERP) at Robert Gordon University (RGU) (SERP reference number: 17-23). Material gathered during this research were coded and kept confidentially by the researcher with only the researcher and supervisory team having access. Paper material were securely stored in a locked cabinet and digital material in password protected PC files both within a restricted area of RGU. Data storage adhered to RGU's data protection policy[6] (in accordance with Data Protection Act 1998) and identifiable personal information being kept separately. Consent forms were stored electronically, and no hard copies were produced. Participants were, also, made aware and consented for their collected data to be used in an anonymised and unidentifiable form in

[6] RGU’s data protection policy: https://www3.rgu.ac.uk/about/planning-and-policy/information-governance/data-protection

future research or disseminated in conference presentations and journal publications.

Table 5.2 below summarises the most important methodological aspects and choices made in the current Delphi study.

Table 5.2 Summary of the methodological characteristics of the current Delphi study

Key aspects	**Choices for current Delphi study**
Purpose of the study	Eliciting key experts' opinion and achieving consensus
Number of Rounds	Three
Consensus level	≥70%
Participants	Heterogeneous group of key experts
Mode of operation	Remote
Intended response rate	≥75%
Anonymity of panel	Full
Communication of media	Electronically via e-mail
Concurrency of rounds	Iterative and sequential

5.4 Results

5.4.1 Panel of key experts

Of the 34 key experts who initially accepted the invitation e-mail, 25 consented to participate giving a response rate of 74%. Of the remaining 9 key experts, 3 could no longer take part due to increased commitments and time constraints, 5 did not respond to round 1 e-mail nor to the follow-up reminder e-mail and thus did not complete the questionnaire and 1 requested an extension higher than one month which was deemed infeasible. Of the 25 key experts who consented to participate, 2 faced technical issues with completing the form and had to discontinue. This resulted in 23 key experts completing round 1 questionnaire.

The panel of 23 key experts participating in round 1 was multinational coming from a range of countries including the UK (*n*=7), Australia (*n*=5), Switzerland (*n*=4), the USA (*n*=3), Canada (*n*=1), France (*n*=1), Hungary (*n*=1), and Netherlands (*n*=1). The panel, also, represented 7 disciplines namely, Nursing (*n*=7), Medicine (*n*=5), Psychology (*n*=4), Engineering (*n*=2), Health sciences (*n*=2), Sociology (*n*=2) and Design (*n*=1). Finally, 15 of the key experts were female and 8 were male. Their reported expertise in the concepts of IPC, theory and visualisation varied across the panel. In most cases, the key experts indicated a combination of expertise as shown in Table 5.3 below.

Table 5.3 Composition of the panel of key experts (*n*=23) in relation to their discipline and expertise

			Expertise								
Discipline	**Male**	**Female**	IPC	Theory	Visualisation	Behaviour change	Antimicrobial stewardship	Intervention prototyping	Quality improvement	Policy	Internal medicine
Nursing	2	5	✓	✓	✓	✓			✓		
Medicine	2	3	✓	✓	✓	✓	✓				✓
Psychology	1	3	✓	✓	✓	✓					
Engineering	1	1	✓	✓		✓					
Health sciences	0	2	✓	✓	✓	✓					
Sociology	1	1	✓	✓	✓	✓				✓	
Design	1	0		✓	✓			✓			
Total	**8**	**15**									

5.4.2 Round 1 themes and sub-themes

Following thematic analysis of round 1 questionnaire, 7 key themes emerged in total each including a wide range of sub-themes. The thematic analysis adopted an inductive approach (i.e., bottom up) where the identified themes and sub-themes were directly linked to the gathered data (Braun and Clarke 2006; Patton 1990). The key themes were theory, visualisation, combining theory and visualisation, planning the development of interventions, healthcare as a system, staff education and sustaining effectiveness. An example of key experts' responses in relation to the first question of round 1 questionnaire is given in table 5.4 below.

Table 5.4 Examples of key experts' responses in round 1 questionnaire

Question: *From your perspective, what types of theory, framework or model have the potential to best inform the development of an intervention to help prevent and control healthcare associated infections (HAIs)? Can you please provide your response below giving any examples and/or explanations?*
Response: The MRC framework for developing and evaluating complex interventions is a nice one to use, but rigidity in its application isn't ideal as it could constrain creativity and progression of new approaches. I would therefore suggest considering integrating a structured framework like this with other, less structured theories and frameworks. [Participant 10, background in Psychology]
Response: Theories that are participatory and which acknowledge and engage with complexity, e.g. video-reflexive methodology. [Participant 17, background in Sociology]
Response: Implementation and behaviour change theories can best inform IPC interventions. In particular Normalization Process Theory is a good example of how clinicians normalise work and gives better understanding of the context in which interventions need to be applied. [Participant 18, background in Health sciences]

Despite the inductive approach adopted, four of the identified themes (theory, visualisation combining theory and visualisation and sustaining effectiveness) were directly linked to the round 1 questionnaire, which may suggest a deductive approach (i.e., top down where themes are attempted to fit into pre-existing coding frames). As such it appears that a combination of the inductive and deductive approach is present. A detailed presentation of the sub-themes corresponding to each theme can be found in Appendix 15. The identified themes are outlined in sections 5.5.2.1-5.5.2.7 and indicative quotes by key experts are provided.

5.4.2.1 Theme 1: Theory

The theme of theory clearly emerged primarily from the first question of the questionnaire. The panel of key experts provided both general and specific examples of theories that have the potential to best inform the development of an intervention to help prevent and control HAIs. Key experts, also, emphasized there is an overwhelming amount of theories which renders their justified selection challenging. One expert noted that

> *"I feel overwhelmed by the amount of theories/frameworks/models and it is easy to feel discouraged to advance in this field."* (medical doctor)

and another wrote that

> *"I will be biased towards the theories/frameworks/models I know best […] The main problem is how to translate them easily in clinical practice."* (infectious diseases specialist)

The importance of understanding the behaviour and its causal factors was, also, highlighted. One expert mentioned that,

> *"It would be important to first understand the causes associated with this. Are factors associated with attention and decision processes? Forgetfulness? Environmental barriers (lack of accessibility to hand washing gels, lack of time)? Once understanding of the causes would be present I would say that theories that focus on the role of habit would be relevant to use here."* (psychologist, health humanities)

One expert commented that,

> *"I am not aware of any HAI specific theory"* (psychologist) *and another one that "I believe that there is something valuable in almost all theories/frameworks/models."* (infectious diseases specialist)

Taking the above into consideration, determining what theoretical approach has the potential to best inform interventions is not a fast track process and is tightly linked to the behaviour itself, the context, the people involved in it as well the experiences and background of the researcher.

5.4.2.2 Theme 2: Visualisation

Among the various visualisation examples provided by key experts, the importance of HH and hands' impact in pertinent visualisations were evident. One expert noted that

> *"An obvious visual are reminders for (correct) hand washing/rubbing"* (psychologist)

and another one that

> *"[…] bugs are invisible, which is some of the problem, so visualisation of the bugs is also useful (e.g. by doing cultures of staff workers' hand prints)."* (sociologist)

Key experts, also, highlighted that infection pathways should be visualised in an attempt to raise awareness of the issue among healthcare staff. In relation to this an expert commented,

> *"I think visual/ video mapping that succinctly represents the pathways to infection within hospital sites is important but also that these are tailored to different kinds of workforce rather than part of a general awareness raising"* (academic nurse, health sciences)

and another one that,

> *"Infection control is about the movement of objects, people, bugs, across spaces and over time. So, effective visualisation of infection control practice needs to have the capacity to represent the spatial and temporal movement (e.g. video)."* (sociologist)

Similarly, another expert wrote,

> *"Visualisation that demonstrates transmission and also pathogen reservoirs."* (academic nurse)

As in the case of the theme of theory, experts noted that the selection of visualisation depends on what the intervention is intended to achieve,

> *"This depends on what the intervention is intended to achieve. Linked to my previous response, this depends on the audience and intended effect. In taking a more sceptical view one could ask if visualisations are: really effective in informing these kinds of interventions; and/or would only be effective in certain conditions (such as used in conjunction with other interventions); or would need different kinds of visualisations for different kinds of data being used together. To properly address this question, it would be useful to have - or compile - a taxonomy of 'visualisation' types."* (designer)

Notwithstanding visualisations have to be clear enough as this impacts on memory and thus behaviour change. A key expert commented that,

> *"Concrete examples and visual. Concrete imagery and language is encoded into memory and retrieved from memory more easily and meaningfully than abstract ones. it is therefore more accessible and more effective in learning and altering behaviours and understandings."* (psychologist)

and another one that,

> *"A fuller understanding of the persuasive role of language in reducing infection is much-needed. Language use (written and spoken) may visibilise infection intracranially and so clearly identifying the links between word/ phrasing choices and infection control intervention could prove helpful."* (academic nurse)

5.4.2.3 Theme 3: Combining theory and visualisation

Combining theory and visualisation received thoughtful attention by key experts and emerged as another theme. In line with the comments in theme 2 regarding the importance of clarity of the selected visualisations, the combination of theory and visualisation needs to clear and concise. A key expert mentioned that,

> *"Narrative theory and cognitive load/overload for me go hand in hand. if you can get the narrative to be clear and concise, there should not be cognitive load. Carefully designing and applying theories applies nicely to the first stage of the MRC framework. It is a bit trickier to tie in the decision science and the health behaviour models, but it can be done. These would apply more so to the content (health model) and presentation (decision science model) of an intervention."* (psychologist)

Harnessing current approach and use of combinations characterised by simplicity was highlighted as being important by another key expert,

> *"Use what we already have at our disposal - we should not be reinventing wheels for the sake of it. Multimodal strategies and BCW are ripe for exploitation - we need to aim for the simplicity on the other side of complexity."* (nurse)

Another expert suggested that,

> *"I think COM-B model can be combined with videos."* (health psychologist)

whereas another one noted,

> *"Video-reflexive ethnography and video*." (physician) may be a useful combination.

5.4.2.4 Theme 4: Planning the development of interventions

A number of key experts emphasized the importance to carefully plan the development of interventions that combine theory and visualisation. Within this ambit, the importance of identifying behaviour barriers and facilitators as well as to consider service users perspectives and opinions was evident. An expert highlighted the need to

> *"Consider service user perspectives and opinions when planning and implementing interventions these are crucial to successful*

implementation, determine facilitators that encourage the current behaviour of HCWs and determine the barriers to changing the behaviour of HCWs." (nurse)

The setting and the type of HAI were, also, suggested to play an important role. A key expert noted that,

"The type of multifaceted intervention that is likely to succeed will depend on the type of HAI intervention you are studying (HH might be different from prevention of catheter-associated bacteremia) and the particular setting." (infectious disease specialist)

Another key expert explained that the planning of the development needs to follow a stepwise approach,

"I would recommend to follow a stepwise approach starting with identifying relevant behavioural determinants in preventing HAI's, determining corresponding BCT's and behaviour theories, and subsequently develop visualizations that are suitable for delivering these BCTs." (academic nurse)

5.4.2.5 Theme 5: Healthcare as a system

The importance to perceive healthcare as a system was highlighted by a number of key experts. A key expert commented on the multifaceted nature of healthcare as a system,

"The idea is simply that to understand the causes of challenges in a system, it is necessary to understand the system, and solutions will likely come from multiple system domains. The definition of the system domains have matured over the years, but I use organization, tools and technology, tasks and processes, physical environment, people, and the external environment." (human factors engineer)

Another key expert made a distinction between changing the system and the individuals within it suggesting that, *"In my experience, it is often more efficient to change the system, rather to try to change professionals at an individual level."* (infectious disease specialist)

Another expert wrote of the importance to disentangle the confounders within the system,

"The IPC/HAI areas are fraught with 'multiple confounders' and a 'complex entanglement' of issues. One of the approaches might be to make this multiplicity of confounders and complexity of the ecosystem etc clearer, and visualisation approaches may have an important role here, to help get everyone on the same page and to help us properly understand the nature of the problem - before we endeavour to develop what might be appropriate interventions." (designer)

5.4.2.6 Theme 6: Staff education

The concept of staff education emerged across round 1 questionnaire from responses related to theory, visualisation and sustaining the effectiveness of pertinent interventions. A key expert highlighted the spectrum of opportunities related to education,

"Considering the spectrum of educational opportunities: undergraduate education, professional development, training (in workforce)." (academic nurse)

Education was seen as an element of investment key in enhancing the effectiveness and sustainability of interventions. In response to how can the long-term effectiveness of interventions be sustained one key expert suggested that,

"Investment. My reckoning would be with a sustainable plan of continuous education, continuous iterative improvement of tools and interventions supported by feedback and robust evidence (I'd use an analogy from the car industry - 'kaizen'). Prospective return on investment from an economic analysis together with

> *the magnitude of the threat might sway the desire to invest."* (designer)

5.4.2.7 Theme 7: Sustaining effectiveness

It was evident that sustaining the effectiveness of interventions is key as advocated by key experts as a direct response to questions 5 and 6 of round 1 questionnaire. Towards sustaining intervention effectiveness, the use of behaviour change techniques was suggested. The provision of feedback of behaviour to healthcare staff was highlighted with a key expert noting,

> *"I think regular feedback about infection rates and behaviour coupled with salient people making sure that this is an important issue may help. Making it easy to do the behaviours is also critical."* (health psychologist)

Another one,

> *"Long term effectiveness probably requires feed-back and ongoing rewards and/or change to the type of behaviour that becomes habituated/automatic, which may depend, initially, on threat of punishment."* (academic nurse)

Other experts commented on the involvement of healthcare staff and management in sustaining effectiveness. A key expert, for example noted,

> *"Engage participants in building a culture of safety. A healthy work environment from a managerial perspective is critical to an intervention being sustained as well."* (academic nurse, educator)

and another one that,

> *"Read widely! So much focus these days is on simple goal setting and behaviour change interventions with disregard for the person or intervention's context and for emotion and/or cognitive processes. All are important in developing a well-rounded intervention."* (psychologist)

5.4.2.8 Development of round 2 statements

A total of 97 statements (Appendix 13) were formed from key experts' responses in round 1 questionnaire. Rather than presenting these statements under the 7 themes as described in 5.5.2, it was decided it would be more beneficial to be presented within 4 broader and more inclusive categories in round 2. These categories were presented in separate parts in round 2 namely, development of interventions, theories/frameworks/models, visualisation and long-term effectiveness and sustainability). As explained in section 5.4.9, and especially in view of the round 1 expert feedback that the content of the interventions would depend on their context and aims, key experts were asked to consider two intervention development scenarios. Experts were then asked to choose one and anchor their subsequent ratings to this particular scenario. In addition, it was ensured that the statements retained the original wording and intent as provided by the key experts in round 1. Furthermore, round 2 statements took a declarative and positive form while being concise and including the intended concepts. As a result of maintaining the factual accuracy of key experts' responses the descriptive validity of the study was enhanced (Brody 1995). Table 5.5 is an example presenting key experts' responses and the consequent statement that was developed.

Table 5.5 Example of development of round 2 statement from round 1 responses

Question: *From your perspective, what types of visualisation have the potential to best inform the development of an intervention to help prevent and control HAIs? Can you please provide your response below giving any examples and/or explanations?*	
Round 1 response [Participant 11, background in nursing]	**Round 1 response** [Participant 31, background in medicine]
[…] To reinforce the infection control content, this patient care simulation included the use of a biosphere to visually depict infectious spread. The powder is invisible to the naked eye, is easily transferrable, and fluoresces under ultra-violet light.	The use of fluorescent dyes to show HCWs about the good performance of the HH technique is nowadays widespread and I believe it is still useful to improve the performance of the gesture - as HCWs can see what parts of the hands were not adequately cleaned.
Combined statement for round 2	
Fluorescent dyes to show HCWs about the good performance of the HH technique to improve the performance of the gesture - as HCWs can see what parts of the hands were not adequately cleaned.	

5.4.3 Round 2 results

Nineteen key experts completed round 2 questionnaire resulting in 82.60% response rate. Of them 10 key experts selected scenario 1 (i.e., systems-wide approach), and 9 selected scenario 2 (i.e., focal approach). Non-respondents were followed-up with two e-mail reminders, but no further response was received.

The four parts and the corresponding statements that key experts had to rate (parts A, C, and D) and rank (part B) are shown below presenting the distribution of experts' responses in relation to the two scenarios. Also, green and red colour are used to denote whether consensus (i.e., ≥70%) was reached or not, respectively.

5.4.3.1 Responses in part A

Key experts in part A were asked to consider 10 statements (table 5.6) related to the development of interventions combining theory and visualisation in the field of IPC and HAI. They were, also, reminded to anchor their ratings based on their chosen scenario. The statements were presented in light of the phrase: "it is very useful to consider:"

Table 5.6 Distribution of key experts' ratings and consensus achieved for statements in part A for scenarios 1 and 2

Statement	Scenario	SD	D	NO	A	SA	Consensus
1. Making interventions engaging, meaningful and pertinent.	1	-	-	-	4	6	**100%**
	2	-	-	-	1	8	**100%**
2. Conducting a meta-analysis of approaches to behaviour change across a number of contexts relevant to public health and not just HAIs.	1	-	2	4	3	1	**40%**
	2	-	-	1	8	-	**89%**
3. Service user perspectives and opinions when planning and implementing interventions as these are crucial to successful implementation	1	-	-	-	4	6	**100%**
	2	-	-	1	2	6	**89%**
4. The barriers to changing the behaviour of HCWs.	1	-	-	-	4	6	**100%**
	2	-	-	-	4	4	**89%**
5. Understanding of the people practicing the behaviour as well as the setting in which they practice the behaviour.	1	-	-	-	1	9	**100%**
	2	-	-	-	2	7	**100%**
6. Understanding what psychosocial and cultural factors affect behaviours.	1	-	-	-	6	4	**100%**
	2	-	-	-	2	7	**100%**
7. Ensuring human factors thinking is embedded in IPC interventions so that visualisation and cues to action become hard wired into IPC.	1	-	-	1	5	4	**90%**
	2	-	-	-	6	3	**100%**
8. The human hand and its complex role as a key part of communication and physical tasks across quickly changing environments and contexts of busy healthcare.	1	-	-	7	2	1	**30%**
	2	-	1	1	1	6	**78%**
9. Understanding the persuasive role of language in reducing infection.	1		-	3	4	3	**70%**
	2		1	2	3	3	**67%**
10. How multimodal strategies underpinned by multiple theories make sense in a practical implementation-focused way.	1		-	2	2	6	**80%**
	2		1	2	3	3	**67%**

Very high consensus rates were achieved for the majority of the statements in both scenarios as can be seen in the above table. Consensus was not reached in statements 2 and 8 for scenario 1, and statements 9 and 10 for scenario 2. Three statements received 100% consensus in both scenarios. More specifically, key experts emphasised understanding of the people practising the behaviour, the healthcare setting as well as the psychosocial and cultural factors that influence behaviour. With these recommendations in mind, intervention may be most useful if they are engaging, meaningful and pertinent.

The comments received in part A highlighted the importance of daily practice as well as the role of healthcare staff especially the disempowered ones in the HAIs problem. More specifically one key expert noted, "You need to differentiate research, and daily practice. The goals and methods might not be the same." (doctor, academic and practitioner - scenario 1) and another one commented, "Systemic change largely involves those disempowered in the hospital hierarchy especially cleaners and nurses. Providing them with strong benefits, wages, training, job security and necessary supplies will help them address the HAI challenge." (sociologist, academic – scenario 1).

5.4.3.2 Responses in part B

Part B included statements related to theories, frameworks and models. In this Part, there were three tables presented to experts based on the three important categories of theories informed by Nilsen's (2015) related categorisation. Instead of indicating a rating for each of these statements as was the case in Part A, key experts were firstly asked to highlight which of the theories, frameworks and models they were familiar with. Based on their indications they were, then, asked to choose their 'top-2' in light of which of them were most useful for their chosen scenario. As explained previously the 'top-2' selection attributed a score to the chosen statements. Tables 5.7, 5.8 and 5.9 show the scores of these statements, with higher scores indicating that these statements were within the 'top-2' selections of most key experts and vice versa. The statements that appear with no cumulative score imply that they have not been selected in any of the key experts' 'top-2'.

Table 5.7 Cumulative scores based on the 'top-2' selections for category 1 in part B statements for scenarios 1 and 2

Category 1: Describing and/or guiding the process of translating research into practice **Statements**	Scenario 1 (system) cumulative score	Scenario 2 (HH) cumulative score
1. Guiding IPC practice and facilitate decision making in determining the best practice as proposed by the Iowa Model of Evidence-Based Practice to promote Quality Care.	1	1
2. Implementation theories which offer a stepwise approach (e.g. Grol and Wensing's model) and take the user through a series of rational and deliberate steps in order to accomplish practice improvement.	4	3
3. Naturalistic decision-making models, such as fast and frugal models which may help the development of interventions that support and exploit naturalistic decision-making processes rather than impeding them.	1	2
4. Co-design and co-development for developing interventions which have a hope of succeeding in IPC.	10	8
5. Quality improvement approaches (e.g. Plan-Do-Study-Act cycles).	5	6
6. The 'stages of change' people are at considering the different readiness levels they experience as in the case of the Trans-Theoretical Model of Change.	-	2
7. Illustrating how knowledge transfers into practice by attending to the phases of awareness, agreement, adoption and adherence as Pathman's model suggests.	-	-
8. Connecting people's behaviours with their emotions to help them see, feel then change as in the case of Kotter's eight-step change model.	3	2

Table 5.8 Cumulative scores based on the 'top-2' selections for category 2 in part B statements for scenarios 1 and 2

Category 2: Understanding and/or explaining what influences implementation outcomes **Statements**	Scenario 1 (system) cumulative score	Scenario 2 (HH) cumulative score
1. Systematically assessing multilevel implementation contexts to explore factors that can determine intervention implementation and effectiveness by using dedicated frameworks as in the case of the Consolidated Framework for Implementation Research.	1	2
2. Theoretical Domains Framework which summarises data from several theories and proposes constructs that could be used to understand and inform interventions in healthcare, namely the implementation of evidence-based guidelines.	-	4
3. Social marketing: a behaviour-change framework that has received growing support as a model for use in relation to infection prevention and control.	3	-
4. 4. Comprehensive Unit-based Safety Program (CUSP) framework to make healthcare safer by improving intra-team's co-operation.	-	-
5. Healthcare factors systems models, as in the case of Systems Engineering Initiative for Patient Safety model.	2	2
6. Theories that explain differences between doctors' and nurses' IPC practices (e.g. Bourdieu's theory of practice).	2	2
7. Identifying intervention functions and policy categories considering what is understood about the targeted behaviour using approaches as in the case of the Behaviour Change Wheel.	2	1
8. Social Cognitive Theory (outcome expectation, self-efficacy, barriers and facilitators) to understand the causal factors of the behaviour.	3	1
9. Psychological decision-making models, as in the case of Theory of Planned Behaviour.	-	1
10. Social science theories, as in the case of Roger's Diffusion of Innovation theory, to help understand how to adapt interventions to a specific individual or group.	2	-
11. Psychological models that attempt to explain and predict health behaviour (e.g. Health Belief Model).	-	3
12. BASNEF (the Behaviour, Attitude, Subjective Norms, and Enabling Factors) model to study behaviours, change them and to define the factors effective on individuals' decision making.	-	-
13. Leventhal's common-sense model of health beliefs and behaviours model which considers not only human behaviour but also emotions and the context of behaviour.	1	-
14. Affect Theory and the role of affects towards learning and change.	-	1
15. Theories that facilitate learning as in the case of Kolb's experiential learning theory where the learner grasps information and transforms it so that it is meaningful to the individual.	-	5
16. Theories targeting healthcare worker safety using reflective practice (e.g. Schön's theory) and verbal protocol analysis (e.g. Simon's theory) to evaluate clinical decision making.	-	2

17. COM-B model: capability, opportunity, motivation for behaviour change.	4	2
18. How clinicians normalise work as in the case of Normalization Process Theory that gives a better understanding of the context in which interventions need to be applied.	2	-
19. Understanding the cause of challenges in a system by understanding the system through the lens of a Macro-ergonomics approach (e.g. Socio-technical Systems theory).	2	-

Interestingly, co-design and co-development as a theoretical approach were most frequently chosen in the experts' 'top-2' in both scenarios followed by quality improvement approaches. This may denote the importance of these approaches in the process of translating research into practice. Of the 19 theory-related statements in category 2, 11 were chosen by experts in their 'top-2' for scenario 1, and 12 were chosen by experts in their 'top-2' for scenario 2. Although there was variation in the identified cumulative scores, the COM-B model appeared to be most useful for key experts who chose scenario 1 (i.e., developing systems-wide behaviour change interventions). This suggests that a more inclusive approach as in the case of COM-B may be more useful for the design of systems-wide interventions. Theories facilitating learning (e.g. Kolb's experiential learning theory) seemed to be most useful according to key experts who chose scenario 2 (i.e., developing focal behaviour change interventions). This indicates that learning-based theories may have the potential to best inform focal interventions involving teams of healthcare staff.

Table 5.9 Cumulative scores based on the 'top-2' selections for category 3 in part B statements for scenarios 1 and 2

Category 1: Evaluating implementation **Statements**	Scenario 1 (system) cumulative score	Scenario 2 (HH) cumulative score
1. Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) framework for program design which addresses both environmental factors and individual factors, such as knowledge, attitudes, and beliefs.	4	6
2. The Medical Research Council (MRC) framework for developing and evaluating complex interventions.	5	3

Two frameworks formed category 3 of part B thus the subsequent scores may not indicate the presence of a fruitful pattern. Despite this, the MRC framework appeared to be favoured over the PRECEDE framework by experts who chose scenario 1. On the other hand, the PRECEDE framework was favoured over the MRC framework by experts who chose scenario 2 (table 5.8).

5.4.3.3 Responses in part C

Based on the findings in table 5.10, 11 out of 24 statements related to visualisation achieved consensus in both scenarios. Varied consensus was achieved for one of the two scenarios across 6 statements, whereas the 70% consensus threshold was not reached in either across 6 other statements (table 5.10). One key expert who chose scenario 2, did not provide any ranking for statements 5-24. Thus, consensus for these questions was calculated considering that 8 key experts (and not 9) provided their responses. As it can be seen in table 5.10 three particular visualisations received high consensus ratings. More specifically, key experts in scenario 1 (6 out of 10) and 2 (7 out of 9) strongly agreed that visualisations demonstrating transmission of pathogen and reservoir have the potential to be most useful. Video mapping was highly recommended by scenario 1 experts (5 out of 9 strongly agreed) as a specific visualisation approach to represent pathways to infection within hospitals. The use of lab simulations allowing learners to apply IPC skills and visually depict the spread of pathogens was another approach highly suggested by scenario 2 experts (8 out of 9 strongly agreed). These suggested visualisations reveal the important role of visualising the spread of pathogens and their pathways in the IPC challenge.

Table 5.10 Distribution of key experts' ratings and consensus achieved for statements in part C for scenarios 1 and 2

Statement	Scenario	SD	D	NO	A	SA	Consensus
1. Visualisations that help one understand the complexities of a system.	1	-	1	1	4	4	**80%**
	2	-	2	-	2	5	**78%**
2. Visualisations that demonstrate transmission and pathogen reservoirs	1	-	-	1	3	6	**90%**
	2	-	-	-	2	7	**100%**
3. The shape of objects when developing interventions.	1	-	-	7	3	-	**30%**
	2	-	1	4	3	1	**45%**
4. Concrete imagery and language for learning and altering behaviours.	1	-	1	3	5	1	**60%**
	2	-	-	2	2	5	**78%**
5. Smart phone applications for educational/induction and/or reminder purposes.	1	-	-	-	6	3	**100%**
	2	-	-	2	4	3	**78%**
6. Colourful posters for conveying information and raising awareness.	1	-	2	-	4	3	**78%**
	2	-	2	-	5	2	**78%**
7. Short videos of staff and carers modelling the appropriate behaviours.	1	-	-	1	5	3	**89%**
	2	-	-	-	4	5	**100%**
8. Visual reminders for correct hand washing/rubbing.	1	-	1	1	4	3	**78%**
	2	-	-	-	5	4	**100%**
9. Simulation in the lab to allow the learner to apply their IPC-related skills using biosphere (fluoresces under ultra-violet light) to visually depict the spread.	1	-	-	1	5	3	**89%**
	2	-	-	-	1	8	**100%**
10. Visual/ video mapping that succinctly represents the pathways to infection within hospital sites.	1	-	-	-	4	5	**100%**
	2	-	-	1	3	5	**89%**

11. Video Reflexive Ethnography to show people what they are doing as others see them, and reflect on their unconscious or habituated actions.	1	-	-	3	3	3	**67%**
	2	-	-	2	2	5	**78%**
12. Dynamic animations, and hypermedia learning environments for education and instruction purposes.	1	-	-	3	4	2	**67%**
	2	-	-	2	5	2	**78%**
13. Fluorescent dyes to show HCWs about the good performance of the HH technique to improve the performance of the gesture - as HCWs can see what parts of the hands were not adequately cleaned.	1	1	1	1	4	2	**67%**
	2	-	-	-	3	6	**100%**
14. New technologies that provide direct and objective visual feedback on hand rubbing technique (e.g. Hand-in-Scan and SureWash devices).	1	2	1	2	2	2	**45%**
	2	-	-	1	3	5	**89%**
15. HCWs video recordings (e.g. use of cameras mounted in their heads) followed by analysis of their gestures to study the hand-surface or hand-patient touches in order to map these interactions.	1	-	2	3	3	1	**45%**
	2	1	2	1	2	3	**56%**
16. 3D-technology/virtual reality where HCWs can actually see their hands contaminated during healthcare when performing simulation-based training.	1	-	-	2	5	2	**78%**
	2	-	2	-	2	5	**78%**
17. Internet-based social media (e.g. Twitter, LinkedIn, IPC blogs).	1	2	-	3	1	3	**45%**
	2	1	-	5	3	-	**34%**
18. Automatic sink lights as a prompt for clinician HH.	1	1	-	5	2	1	**34%**
	2	-	1	5	3	-	**34%**
19. Training-, and induction-based tablet applications using interactive visuals related to IPC and HAIs.	1	-	-	2	5	2	**78%**
	2	-	-	2	7	-	**78%**
20. Screen savers with gain-framed messages to influence HCWs' HH behaviour.	1	2	1	2	3	1	**45%**

	2	-	2	4	2	1	**34%**
21. Flashing lights on alcohol-based hand-rubs as a prompt to HH.	1	1	1	4	1	2	**34%**
	2	-	1	7	1	-	**11%**
22. Warning signs prompting HCWs to wash their hands.	1	1	1	3	2	2	**45%**
	2	-	2	2	4	1	**56%**
23. Infographics to convey HAIs-related information.	1	1	-	1	5	2	**78%**
	2	-	-	4	4	1	**56%**
24. Visualisation of the bugs (e.g. by doing cultures of HCWs' hand prints)	1	-	1	1	5	2	**78%**
	2	-	-	-	6	3	**100%**

Key experts provided various comments regarding part C statements. Amongst them, the beneficial role of video-based visualisations as well as related concerns were highlighted. A key expert noted that, "On statement 7 you might also consider showing videos of inappropriate behaviour. Sometimes our minds like to be critical." (nurse, academic – scenario 2). Another expert commented that, "I really like the idea of camera due to personalisation making it meaningful to the person but think this would be detrimental to patient care (patients may be suspicious) possibly uncomfortable throughout the day, and – finally – would be nightmarish to get through NHS ethics." (psychologist, academic – scenario 1). A more sceptical comment about the use of cameras in sites was highlighted by another expert explaining that "staff will be concerned about the ethics of camera intrusion into personal care scenarios. The culture of threat in healthcare sites is very high and approaches should avoid excessive 'warnings' and admonition to comply. The virtue of visibilisation lies in affording staff clearer perspectives on infection pathways to and realistic strategies to reduce if not eliminate infections." (nursing academic – scenario 2).

The importance of incorporating visualisation within multimodal interventions was, also, embraced. A key expert highlighted that, "Useful to consider many of these [i.e., visualisations] but only in the context of a holistic multimodal improvement strategy – not as a unimodal intervention" (nurse consultant in policy organisation – scenario 1). The need for multimodal interventions was further supported by another expert who noted that "Strategies certainly need to be multimodal and theories probably help to order one's thoughts about how to implement them in a logical and effective manner." (doctor in academia – scenario 2).

5.4.3.4 Responses in part D

Part D of round 2 questionnaire sought to explore experts' consensus on what BCTs are useful to inform behaviour change interventions and how can the long-term effectiveness of such interventions be sustained. The related statements and the corresponding consensus levels achieved are shown in table 5.11.

Table 5.11 Distribution of key experts' ratings and consensus achieved for statements in part D for scenarios 1 and 2

What behaviour change techniques are useful to inform behaviour change interventions? Statement	**Scenario**	**SD**	**D**	**NO**	**A**	**SA**	**Consensus**
1. Instruction on how to perform the behaviour	1	-	-	-	5	4	**100%**
	2	-	-	-	6	3	**100%**
2. Feedback on outcomes of behaviour	1	-	-	1	3	5	**89%**
	2	-	-	-	4	5	**100%**
3. Feedback on behaviour	1	-	-	-	4	5	**100%**
	2	-	-	-	3	6	**100%**
4. Goal setting (behaviour)	1	-	1	1	4	3	**78%**
	2	-	2	-	4	3	**78%**
5. Goal setting (outcome)	1	-	1	2	4	2	**67%**
	2	-	2	-	4	3	**78%**
6. Restructuring the physical environment	1	-	-	-	4	5	**100%**
	2	-	1	1	2	5	**78%**
7. Action planning	1	-	-	2	4	3	**78%**
	2	-	2	2	4	1	**56%**
8. Information about health consequences	1	-	1	-	5	3	**89%**
	2	-	1	1	4	3	**78%**
9. Social comparison	1	-	1	3	3	2	**56%**
	2	-	1	2	4	2	**67%**
10. Prompts/cues	1	-	1	-	6	2	**89%**
	2	-	-	-	6	3	**100%**
11. Habit formation	1	-	-	1	5	3	**89%**
	2	-	-	-	1	8	**100%**
12. Identification of self as role model	1	-	1	2	3	3	**67%**
	2	-	-	-	4	5	**100%**
13. Behavioural practice/rehearsal	1	-	-	1	6	2	**89%**
	2	-	-	-	3	6	**100%**
14. Material incentive (behaviour)	1	-	-	5	3	1	**45%**
	2	-	-	3	4	1	**56%**
15. Social reward	1	-	-	3	5	1	**67%**
	2	-	2	-	5	2	**78%**

How can the long-term effectiveness of such interventions be sustained?

Statement	Scenario	SD	D	NO	A	SD	Consensus
16. More involvement and understanding on the part of the administration.	1	-	-	1	5	3	89%
	2	-	1	2	3	3	67%
17. Regular feedback about infection rates and behaviour coupled with salient people.	1	-	-	-	6	3	100%
	2	-	2	-	5	2	78%
18. Periodic competition among HCWs.	1	-	-	4	4	1	56%
	2	-	2	3	3	1	45%
19. Establishing some form of outstanding events (e.g. world HH day).	1	-	1	4	4	2	67%
	2		1	2	3	3	67%
20. Providing technical solutions and automatization.	1	-	1	1	5	2	78%
	2	-	1	-	3	5	89%
21. Making it easy to do the behaviours.	1	-	-	2	2	5	78%
	2	-	-	-	1	8	100%
22. Adopting recommendations in training and becoming a norm in clinic.	1	-	1	1	2	5	78%
	2	-	1	2	4	2	67%
23. Making structural changes in the environment.	1	-	-	-	4	5	100%
	2	-	1	1	4	3	78%
24. Attaching an emotional component in such interventions.	1	-	-	5	1	3	45%
	2	-	1	3	3	2	56%
25. Engaging HCWs in building a culture of safety.	1	-	-	-	5	4	100%
	2	-	-	-	4	5	100%
26. Establishing a healthy work environment from a managerial perspective to an intervention being sustained.	1	-	-	3	3	3	67%
	2	-	-	2	1	6	78%
27. Making the intervention easy to be incorporated into everyday practice.	1	-	-	-	4	5	100%
	2	-	-	-	-	9	100%
28. Frequent re-evaluation of interventions for salience and accuracy.	1	-	-	1	5	3	89%
	2	-	-	1	3	5	89%
29. Investment with a sustainable plan of continuous education, continuous iterative improvement of tools and interventions supported by feedback and robust evidence.	1	-	-	1	5	3	89%
	2	-	-	1	3	5	89%

30. All HCWs to take IPC improvement strategies as they own responsibility and not only the IPC group.	1	-	-	2	4	3	**78%**
	2	-	1	1	1	6	**78%**
31. Creation of regional networks.	1	-	1	2	3	3	**67%**
	2	-	1	3	4	1	**56%**
32. Defining clear objectives, clear plan of monitoring and feedback, surveillance and clear empowerment of the IPC group, continuous training and a defined programme for new HCWs in the institution.	1	-	-	3	1	5	**67%**
	2	-	-	1	2	6	**89%**
33. Habit formation for behavioural maintenance.	1	-	-	2	3	4	**78%**
	2	-	-	-	3	6	**100%**
34. Elements of shocking (like the pictures of lung tumours on tobacco packets).	1	-	-	5	3	1	**45%**
	2	2	-	3	3	1	**45%**

Consensus was achieved by key experts for both scenarios in 9 out of 15 statements related to what BCTs are useful to inform behaviour change interventions. These BCTs were: instruction on how to perform the behaviour, feedback on outcomes of behaviour, feedback on behaviour, goal setting (behaviour), restructuring the physical environment, information about health consequences, prompts/cues, habit formation and behavioural practice/rehearsal. Of the least useful BCTs, based on the low consensual agreement across the two scenarios, were: social comparison and material incentive (behaviour).

Among experts who chose scenario 1, two of the BCTs namely instruction on how to perform the behaviour and feedback on behaviour, received 100% consensus. This indicates the importance of providing explicit instructions and feedback to healthcare staff about how to perform hygiene-related practices. Considering that consensus was achieved by experts who chose scenario 1 (i.e., systems-wide approach) then these two BCTs have the potential facilitate HCWs daily practice. Corroborating this assertion was a comment by a key expert who highlighted that, "I think that a fundamental area of focus is the human hand and its complex role as a key part of communication and physical tasks across quickly changing environments and contexts of busy healthcare. Whilst HH compliance has diminishing efficacy after about 40%, it is vital that clinicians can visibilise the impacts of the hand" (nurse, academic – scenario 2). Among experts who chose scenario 2, feedback on behaviour along with habit formation and behavioural practice/rehearsal received the highest ratings. This finding may suggest that habits regarding hygiene practices and related behaviours can be formed and sustained in smaller teams within focal interventions as in the case of scenario 2 than system-wide interventions involving the whole institution.

The remaining statements of part D pertained to particular actions for sustaining the long-term effectiveness of interventions. High consensus was achieved for both scenarios in 10 statements out of 19 statements. The highest agreement (i.e., 100%) was achieved for both scenarios in statements referring to engaging HCWs in building a culture of safety and making the intervention easy to be incorporated into everyday practice. Five statements did not reach consensus in either of the two scenarios with the use of elements of shocking and periodic competition among HCWs seen as least effective for sustaining effectiveness.

The important role of healthcare staff in the HAIs issue was not only highlighted in relation to the development of interventions (see comments in part A responses) but was also embraced as a means to successful and sustainable interventions. A key expert in part D commented that "Engaging the actual bedside caregivers in the creation of policies and interventions goes a long way in getting buy in. Connect with them early and often." (nurse, academic – scenario 2). Another key expert emphasised team collaboration within adjusting environments, "The priority should be adjusting environments and resources for cleanliness that maximise HH in the context of skin maintenance and priorities around levels of patient engagement requiring radical HH preparation. […] It would be much better to place an emphasis of collaborative team working as opposed to competitive individuated success in behaviour change." (nursing academic – scenario 2)

5.4.4 Round 3 results

Eighteen key experts completed round 3 questionnaire resulting in 95% response rate. Following analysis of round 2, of the 65 statements requiring a rating in parts A, C and D 40 reached consensus among experts who chose scenario 1 and 45 reached consensus among experts who chose scenario 2. The remaining statements became the final round 3 content. For each of them key experts were reminded of their round 2 ratings and presented with the panel's ratings distribution for the chosen scenario. Based on this feedback, experts were asked to either retain their initial rating or alter it. For the statements in part B, key experts were reminded of their 'top-2' selection along with the cumulative score of all statements. Similarly, they were asked to consider this information and either retain their initial 'top-2' selection or choose another one.

Following the provision of feedback, 5 additional statements reached consensus among experts who chose scenario 1: in part A statements 3 (from 60% to 80%) and 13 (from 67% to 80%), and in part D statements 15 (from 67% to 90%), 26 (from 67% to 80%) and 32 (from 67% to 90%). The ranking for part B statement remained unchanged. Five additional statements, also, reached consensus among key experts who chose scenario 2: in part A statements 9 (from 67% to 78%) and 10 (from 67% to 78%), in part C statement 23 (from 56% to 78%) and in part D statements 16 (from 67% to 89%) and 22 (from 67% to 78%). No changes in the 'top-2' selections were observed in part B.

Statement 2 of part A about conducting a meta-analysis of approaches to behaviour change, received thoughtful attention by two key experts. One of them noted that, "I would add a caveat to my answer to statement 2, as a meta-analysis is 'expensive' in time and potentially resources, and the nature of my work and associated funding could prevent such a meta-analysis taking place." (designer in academia – scenario 1) and another one that "a meta-analysis would need to be very specific to achieve a meaningful and manageable outcome. Perhaps a systematic review would be better suited?" (psychologist academic – scenario 1).

5.5 Discussion

5.5.1 Key findings

This e-Delphi study set out to harness expert knowledge to identify types of theory and visualisation that can optimally be combined and best inform the development of pertinent behaviour change interventions in the field of HAIs and IPC. The expert panel was made up primarily of academics and healthcare professionals with expertise in the concepts of IPC, theory, visualisation and development of behaviour change interventions.

Three Delphi rounds were conducted with a response rate of 74% in round 1, 82.60% in round 2 and 95% in round 3 and an international panel of 18 key expert completed all rounds. Analysis of round 1 questionnaire resulted in the development of 97 statements within 7 thematic areas. At that point two important decisions were taken for the development of round 2. The first decision was to incorporate the statements within 4 broader themes and not within the 7 themes identified in round 1. The second decision included the development of two intervention scenarios for which experts were asked to consider and anchor their round 2 ratings on one of them.

In scenario 1 intervention development considered a systems-wide approach involving the whole healthcare organisation aiming to reduce infection rates. On the other hand, scenario 2 focused on developing focal interventions within small healthcare teams aiming to increase HH compliance. This decision was envisaged to allow key experts to conceptualise the statements more effectively based on more specific applications that would relate to context, aims and their relevant expertise. Although not intended nor could have it been determined, the distribution of experts between the two scenarios in round 2 was balanced (10 experts in scenario 1 and 9 experts in scenario 2).

The statements presented to key experts in round 2 were related to the development of interventions, theory, visualisation and long-term effectiveness and sustainability of interventions. This resulted in variously rated statements which along with the two scenarios provided a range of collective agreement from as low as 11% to as high as 100%. Recognising the plethora of options available a key expert in round 1 commented that, "I am afraid you will end up concluding that 'any intervention might work in any setting', as for antimicrobial stewardship interventions." This quote is reflective of the study's findings which showed that that experts did not reach consensus on some statements and that, even where consensus reached, some interventions were more universal and some more specific to each scenario (as in figure 5.2).

Therefore, the findings of the current Delphi study offer a 'menu of options' elicited and agreed among key experts rather than a set of definitive answers. Figure 5.2 below represents this 'menu of options' and incorporates the statements which achieved the highest consensus ratings for scenarios 1 and 2 for each of the four parts (i.e., development, theory, visualisation, effectiveness). However, the fact that other options were not included in the figure does not imply that they are not useful nor that they cannot inform pertinent interventions.

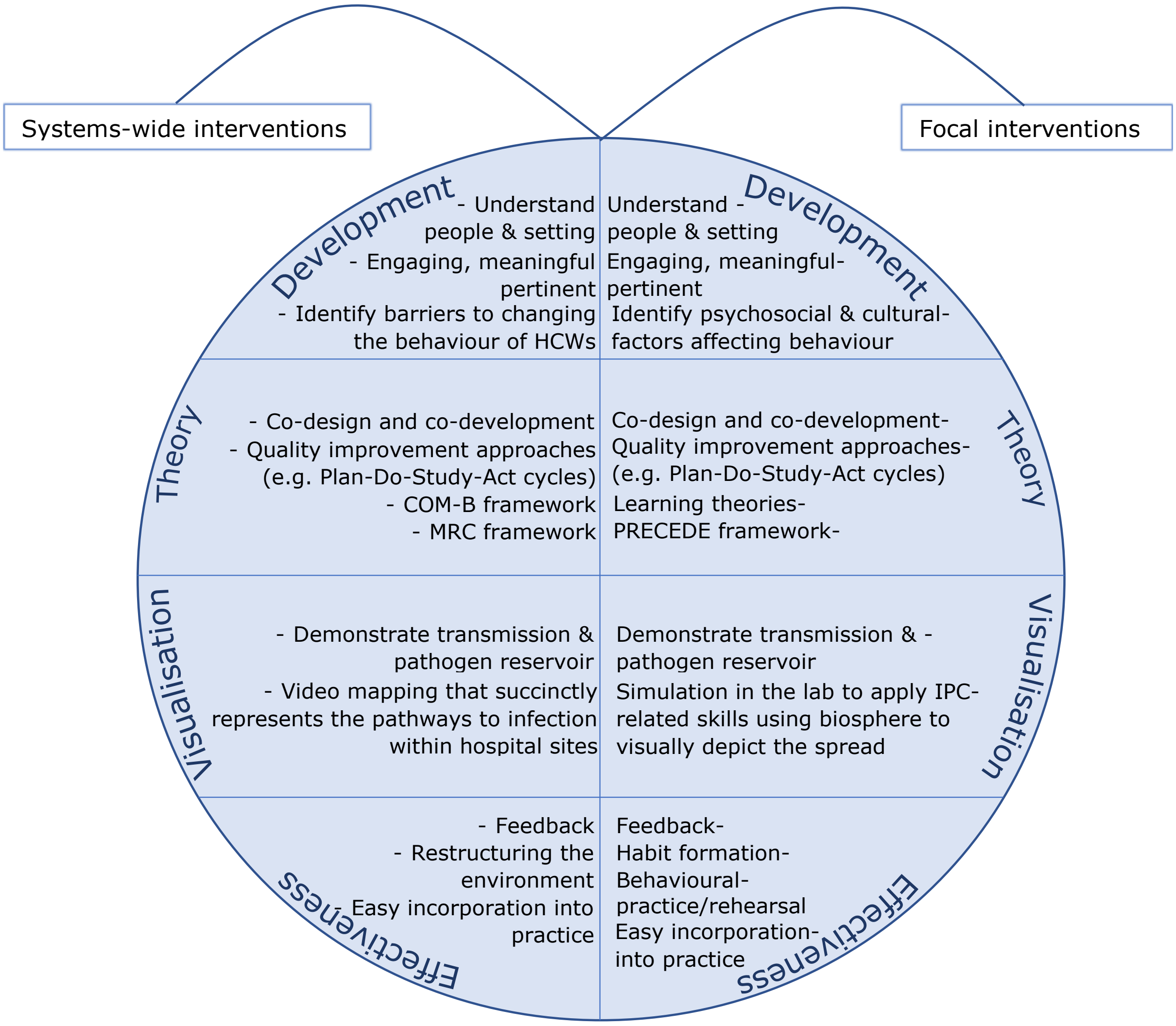

Figure 5.2 Menu of intervention options which received high consensus regarding the development, theory, visualisation and effectiveness

The above 'menu of options' should be viewed in light of what key experts commented on about developing multimodal interventions based on multiple components. One key expert suggested we should, "use multimodal improvement strategies based on system change, reminders in the workplace feedback and monitoring, goal setting, leadership commitment, surveillance, education and training as they have been shown to help improve HH compliance in health care facilities.", and another noted that, "in addition to maximizing the multimodal strategy of WHO - which draws on many behavioural theories including PRECEDE PROCEED, very important to ensure human factors thinking is embedded in IPC interventions. This way, visualisation and cues to action become hard wired into IPC." Lending further support to the importance of multimodal interventions in the context of IPC was IR2 presented in Chapter 4. IR2 findings suggested that multicomponent interventions may form the basis for effective and sustainable interventional solutions. This assertion is, therefore, strengthened by the findings of the current Delphi study.

Although, the completion of all 3 rounds resulted in valuable outcomes, particular statements that received either very high or very low consensus merit further discussion. With respect to the development and effectiveness of interventions it was highly agreed in both scenarios that the involvement of healthcare staff is key. This was, also, a central point articulated by Zingg et al. (2015). As part of their systematic review, it was recognised that healthcare staff can contribute in reducing HAIs and improve patients' safety through their availability, the involvement of frontline staff in education and training, the engagement and participation of 'champions' in promoting interventional solutions and creating a positive organisational culture.

In terms of the theories, models and frameworks which key experts were asked to rank (i.e., 'top-2'), co-design as well as qualitive improvement approaches (e.g. PDSA cycles) were, by some way, the two most favoured theoretical-based approaches in both scenarios. This underscores the emphasis given by key experts on approaches guiding the process of knowledge translation in the development of interventions. This is supported by IPC study examples that exist in the literature that reported using co-design (e.g. Loudon, Macdonald and Macduff 2015; Meyers, Jacobsen and Henderson 2018) and quality improvement approaches (e.g. Wale et al. 2016; Lambl et al. 2018).

Of the statements related to visualisation, what is interesting is the rejection of the statement related to the use of Internet-based social media. This finding contradicts research evidence supporting the use of social media regarded as powerful tools in IPC (Pan et al. 2016; Mitchell et al. 2017). The use of social media seemed not to be on the radar of the current expert panel. This may indicate the panel's preference to more 'traditional' and face-to-face approaches towards addressing the IPC and HAI challenge.

When key experts in both scenarios were asked to consider statements related to the long-term effectiveness of interventions, they unanimously rejected statements related to periodic competition among healthcare staff, the use of emotional components and elements of shocking in interventions. With regard to introducing periodic competition this may be seen as an obstacle to fostering teamwork and collaboration which are essential elements for IPC (Dellinger 2016). The use of emotional aspects in interventions has resulted in positive outcomes elsewhere. For example, a cluster-randomised trial by Biran et al. (2014) implemented an intervention based on emotional drivers and resulted in substantial increases in handwashing. However, their study targeted at members of the public with the potential presence of cultural aspects (i.e., the study was conducted in rural India). This may suggest that emotional aspects may not be as effective for changing behaviour among healthcare staff compared to other non-professional populations. Similar studies, implementing emotion-based approaches presented mixed findings. For example, the study by Gaube et al. (2018) reported on a HH electronic monitoring and feedback system displaying visual cues which were either emoticons (frowny and smiley face) or images of human eyes (feeling of being observed). The authors suggested that the use of emoticons was more effective in improving HH behaviour because of the activation of injunctive norms among participants (i.e., 'I should do, what ought to be done') (Schultz et al. 2007). In another study, King et al. (2016) tested whether psychological priming (Bargh 1992) through exposure to visual (i.e., male and female eyes) and olfactory cues (citrus smell) can alter HH behaviour. Interestingly, male eyes had an effect on HH compliance (compared to female eyes which did not) with the authors suggesting a predominance of men's social influence and authority than women. Conversely, the use of artificial 'watching eyes' has been found to be ineffective elsewhere (e.g. Stella et al. 2019). Taking the above into consideration and in light of the IR2 mapping quadrant (figure 4.3, Chapter 4) more work is needed to explore the optimal types of visual priming and to address the challenges that may affect such interventions.

Another interesting finding was the low agreement for both scenarios on the use of flashing lights as a prompt to HH (e.g. statements 18 and 21 of Part C in table 5.9). Although it seems that flashing lights as part of electronic monitoring approaches may result in improved HH (Marra et al. 2014; Alshehari, Park and Rashid 2018; Benudis et al. 2019), scepticism as to its overall impact on clinical practice exists. For example, Dyson and Madeo (2017) suggested that an electronic HH monitoring and prompt device (i.e., sensor-based badges with flashing lights) resulted in improved HH compliance during the period the device was installed. The authors highlighted that this improvement was multifaceted in terms of prompting healthcare staff to HH, enhancing empathy with patients and improving awareness of the necessity for HH. However, the positive effect was not sustained when the device was removed. The authors also explained that the monitoring system was generally related with negative feelings including irritation, frustration and destruction as expressed by participating healthcare staff. This was the case especially when healthcare staff felt their practice was monitored and guided in such a way. Staff's attempts to 'gaming' the system owing to inaccuracies of the system that were recorded against them were, also, reported (Dyson and Madeo 2017). In the current study, despite the absence of explanations as to the Delphi experts' 'lack of faith' for the use of flashing lights, the low agreement levels may reflect the challenges of this approach especially in relation to clashing with staff's clinical practice. In addition, other challenges tightly linked to the use of monitoring and prompt systems are the need to protect privacy, the design and implementation costs for these systems and potential interference of the wireless system with the medical equipment (Ward et al. 2014; Conway 2016). Taking the above into consideration, further research is required to refine the use of electronic monitoring systems utilising flashing lights for facilitating HH.

5.5.2 Study strengths and limitations

The current Delphi study has a number of strengths and limitations which need to be acknowledged. With regard to its strengths, this is the first Delphi or even consensus-based study to elicit and harness experts' opinions on the concept of theory and visualisation in the wider IPC context. The study benefitted from an international panel of key experts comprised primarily academics and healthcare professionals from various backgrounds and disciplines. This was, thus, key in unifying the aforementioned concepts based on multidisciplinary, interprofessional and multicultural perspectives. In addition, the high response rates enhanced the validity of the study and depicted experts' engagement with the topic. This has highlighted a strong interest in the study's concepts which may indicate potential for further research and development in this field. Another aspect that enhanced the robustness of the study was the systematic and careful selection of the key experts based on specific inclusion criteria. The use of a pilot-tested questionnaire, multiple iterations and provision of feedback also added strength to the study design. All the related processes have been described and retained in a detailed decision trail thus maximising the rigour of the study.

Limitations, however, exist and thus findings must be interpreted with caution. The developed statements in round 2 exceeded the recommended upper limit of 25 statements that a Delphi questionnaire should have (Sackman 1975). This may explain the small number of comments and justifications by key experts for specific statements although they were encouraged to do so at the end of each part within comment text-boxes. The high number of statements is likely to have impacted on the time required to complete the questionnaire. Although, 20-25 minutes seemed to be adequate for completing each of the three rounds questionnaire experts who provided detailed and in-depth comments especially in round 1 may have required more time. However, this did not seem to hinder overall participation. In addition, the decision to develop the statements is believed to be a true and concise representation of the rich data that emerged by experts following round 1 analysis. Other study limitations were the consensus cut-off point at 70% and the number of rounds. Although no international guidance exists around these issues, decisions were taken empirically based on other similar studies as discussed previously and prior to the commencement of the study.

5.6 Conclusion

This Chapter has presented the results of a 3-round Delphi study that aimed to harness expert knowledge to identify types of theory and visualisation that can optimally be combined and best inform the development of pertinent interventions in the field of HAIs and IPC. Key experts recommended a 'menu of options' whose components received high collective agreement. This menu offers insights for the development of two intervention approaches namely systems-wide aiming to decrease infection rates across the healthcare organisation and focal interventions within small teams of the organisation aiming to increase HH compliance. A range of options related to the development and effectiveness of interventions are suggested as well as theory and visualisation approaches are described. It is highlighted that the role of healthcare is key in addressing the IPC and HAIs challenge.

5.7 Reflections and future direction

The Delphi findings strongly suggested that healthcare staff are key in the development and success of IPC interventions combing theory and visualisation. Therefore, the decision to conduct qualitative focus group discussions with healthcare staff (Chapter 6) aimed to further investigate these issues and was supported by the findings of the Delphi study. The 'menu of options' (figure 5.2) as recommended by key experts was, also, presented to focus group participants in the form of short vignettes in order to gather their perspectives and opinions.

Chapter 6

Focus Group Discussions

Chapter 6

FOCUS GROUP DISCUSSIONS WITH HEALTHCARE STAFF FROM INFECTION CONTROL TEAMS AND PAEDIATRIC HOSPITALS: CONSIDERING THE ROLE OF THEORY AND VISUALISATIONS IN BEHAVIOUR CHANGE INTERVENTIONS

6.1 Introduction to the Chapter

This chapter presents the findings of four focus group discussions (Phase 3) with healthcare staff from paediatric services and infection control teams from two Scottish Health Boards. The study is directly linked to the previously conducted Delphi study (Phase 2). The chapter thus provides a detailed account of the decisions taken in relation to the conceptualisation of Phase 3 as well as the selection of the particular settings and recruitment process of healthcare staff. The analysis of the focus group discussions was facilitated by a 6-step thematic analysis (Braun and Clarke 2006). Representative quotes by participating healthcare staff are provided to better illustrate their perspectives and opinions.

6.2 Background

This phase of the study builds on the combination of the three concepts that are fundamental to the thesis, namely HAIs, theory and visualisation which to the current researcher's best knowledge have not been the explicit focus of any previous focus group study with healthcare staff. Other focus group studies have explored reasons for low adherence to hygiene regulations amongst healthcare staff (e.g. Jang et al. 2010; Efstathiou et al. 2011) but none of them investigated the role of visualisation approaches and specific theories and which of them can best inform the development of behaviour change interventions.

6.2.1 Rationale for using focus group discussions in the current study

The focus group discussions were envisaged to form a means to gauging the applicability of the Delphi findings, with the healthcare practitioners at the operational level who have direct engagement with the wider issues of IPC and HAIs. Importantly, this methodological decision was corroborated by the findings of the Delphi study as key experts highlighted the important role of healthcare staff in the success of implemented interventions and thus in addressing the IPC and HAIs challenge. Specifically, the Delphi experts recurrently suggested that healthcare staff should have an active role in the development of IPC-related behaviour change interventions (i.e., co-design and co-development approach) and their voice should be heard in relation to what drivers influence behaviour change. Therefore, exploring some of healthcare staff's unseen and possibly unmet needs was envisaged to be beneficial for the development of the intended recommendations.

6.3 Focus group study aim and research questions

Considering the sequential link of the Delphi study with the focus group discussions, the latter aimed to further inform the development of recommendations for behaviour change interventions combining theory and visualisation in the field of HAIs by drawing upon the everyday clinical practice of healthcare staff. Thus, eliciting staff's perspectives on these issues as well as their opinions on part of the key experts' recommendations (Delphi study) would enhance the evidence base in the field. Therefore, the current focus group study aimed to specifically address the following research questions:

1. What do the focus group participants see as the main issues related to HAIs and adherence to hygiene regulations and what factors can facilitate or hinder their adherence?
2. What are the opinions, perspectives and experiences of the focus group participants (healthcare staff from infection control teams and paediatric services) around HAIs and interventions using theory and visualisation as well as developing more effective ones?
3. How helpful do staff feel the expert recommendations are for their everyday clinical practice?

Therefore, conducting the proposed focus group discussions with healthcare staff (i.e., the individuals who engage with such interventions) was envisaged to help the researcher to gain a better understanding of the staff's experiences and needs, to identify intervention components related to theory and visualisation and ultimately to develop relevant recommendations.

6.4 Ensuring a systematic process in the current study

In order to ensure a systematic process in the current focus group study specific approaches were adopted. These are outlined below and are further discussed later in the Chapter:

- A clear decision trail was used from the conceptualisation of the study to data collection and analysis.
- The methodological decisions pertaining to the sampling process, type of sample, number of participants in each focus group and related sites were justified and taken in light of the study's aim along with literature evidence and guidance that exist.
- The focus group discussions were audio-recorded thus allowing for a detailed and accurate verbatim transcription by the current researcher.
- Transcript analysis was facilitated by the use of NVivo software (QSR International Pty Ltd. Version 11 2015) with the researcher attending dedicated training courses in conducting focus groups and analysing and reporting qualitative data.
- Scrutiny of the process and related feedback has been received by the research team on a frequent basis. Also, the study obtained ethical approval by the researcher's institution as well as the Research and Development (R&D) departments of the NHS Health Boards involved.

6.5 Method of the focus group discussions

The following sub-sections provide details on the procedure of the focus group discussions undertaken including explanations on the sampling method, sample size, participants inclusion and exclusion criteria, the development of the topic guide used in the focus group discussions and the method of data analysis that was adopted.

6.5.1 Sampling

Key aspects related to the sampling process required thoughtful consideration and pertained to the selection of recruitment sites and participants as well as the number of focus groups. The selection of the sampling locations was purposive, with the aim to recruit healthcare staff representing a balanced mix of urban and rural areas. However, this recruitment strategy and the intended balance much depended on the availability of the contacted NHS Health Boards and their interest in participating in the study. In total, four focus groups discussions were conducted, two with specialist infection control teams and two with nurses from paediatric services across two Scottish NHS Boards (an explanation of the participants recruitment is provided below in this section). Although, more Scottish NHS Health Boards were contacted to identify a potential interest in participating in the study, the aforementioned two NHS Health Boards were chosen because of the initial interest in participating by both groups (i.e., infection control team and nurses from paediatric services) and the adequate pool of potential participants. Other NHS Health Boards either did not respond to the initial enquiry, or only one of the two contacted groups within each Health Board did express an interest in participating, or a limited number of healthcare staff could potentially participate.

With regard to the number of focus groups in a study, scarce empirical evidence exists towards determining the adequate number of focus groups required for a study (Carlsen and Glenton 2011; Guest, Namey and Mckenna 2017). The concept of saturation could potentially have guided this process as it is widely considered as the gold standard in qualitative inquiry (Guest, Bunce and Johnson 2006; Guest and MacQueen 2008). However, for practical reasons pertaining to the strict time constraints of this doctoral research and the thorough procedure for obtaining ethical permission the concept of saturation was deemed as practically problematic (Charmaz 2014). According to the recommendation which guided the current study, two or three focus groups for each participant category are adequate (Krueger and Casey 2014). Based on the research evidence outlined above as well as other doctoral theses utilising focus groups with healthcare staff (e.g. Ward 2016; Ismaile 2014) it was decided that four focus group discussions in total would be adequate to explore staff's opinions and perspectives in-depth and thus capture the majority of shared themes.

The recruitment of participants was also purposive, with the intention to relate the samples to the twin foci of the conducted Delphi study. More specifically, it was decided to recruit members of infection control teams and nurses from paediatric hospitals. The rationale for this sample selection is linked to the identified two approaches to intervention development at the conduced Delphi study namely, systems-wide approach (Scenario 1: aiming at decreasing infections rates across the whole institution) and focal approach (Scenario 2: aiming at increasing HH adherence within teams of healthcare staff). The infection control teams are actively involved in tasks related to education, audit, surveillance, advice, outbreak management, research and information across the whole institution and therefore the systems-wide approach better reflected on their role and responsibilities[7]. Similarly, the focal approach to intervention development better reflected on nursing staff from specific departments forming smaller teams with a particular focus on HH. Such teams would likely be found in paediatric hospitals which were additionally envisaged to offer a wide pool of potential participants to be approached and recruited (as paediatric hospitals are comprised of various wards and clinics). Also, the importance of improving adherence to hygiene regulations and particularly hand hygiene in the paediatric setting (Jamal et al. 2012) was taken into consideration.

Having these two types of focus group participants would allow the specific Delphi recommendations (as per scenarios 1 and 2) from Phase 2 to be presented separately across targeted groups of healthcare staff. Consequently, and in light of this categorisation, the final recommendations aimed to be generated as part

[7] Adopted from online source: https://www.nhsggc.org.uk/your-health/infection-prevention-and-control/about-us/

of this doctoral research were envisaged to be more meaningful and likely to offer fruitful insights to the readers.

6.5.2 Sample size

Although, there is no agreement in research literature as to the ideal size of focus group discussions, it is recommended that six to ten participants suffice for a successful focus group (Krueger and Casey 2014; Rabiee 2004). Osborne and Collins (2001) suggested that focus group discussions with four to twelve participants are practical. Based on these recommendations it was intended to include approximately eight participants in each focus group discussion resulting in a total of thirty-two potential participants. However, the actual size of each focus group was determined only after liaising with the gatekeeper of each of these groups and when potential participants were informed about the study and agreed to take part. Further details about the healthcare staff who participated in each group are presented in section 6.6.2.

6.5.3 Inclusion and exclusion criteria

In relation to the infection control focus groups participants were eligible to participate if they were healthcare professionals who were members of the infection control team (e.g. infection control nurses, consultant microbiologists, antibiotic pharmacists) of the two selected Scottish Health Boards. No exclusion criterion was set on the basis of the staff's role within the team or years of experience on their post.

In relation to the focus groups with nurses from paediatric hospitals, participants had to be nurses at any ward or department of the paediatric hospital at the aforementioned two NHS Health Boards. In addition, nurses were not excluded on the basis of their role in the hospital or specialty nor on the basis of the years of experience they had on their post. As a common exclusion criterion for both focus groups, non-registered nurses, bank staff, locum staff and students were excluded from the recruitment. Also, all participants had to be above 18 years old to be eligible to participate (with no upper age limit).

6.5.4 Research governance

The research proposal of the focus group study was scrutinised and received ethical approval by the School of Nursing and Midwifery, Robert Gordon University Ethics Review Panel in May 2018 (SERP reference number: 18-15). Owing to the nature of the focus groups with the recruitment of NHS healthcare staff, R&D permission from both participating NHS Health Boards was necessary to be obtained before the commencing of the study. Following Integrated Research Application System (IRAS) submission, the generated application pack was forwarded to the two NHS R&D offices for granting permission.

Apart from explaining the aim of the focus group discussions and how the study forms an integral part of the current doctoral research, a number of specific ethical, legal, and management issues arising from the proposed study were detailed in the above documents. More specifically:

- All participating healthcare staff took part in the focus group discussions on a voluntary basis.
- No private or confidential information was sought from the participants. Only demographic related information will be gathered using a registration form. It was also made clear that personal privacy was respected in terms of the focus group data being stored and reported in such a way that no individual would be identified personally.
- As mentioned above participants were free to no longer take part in the study without providing any reason even if they initially confirmed their participation. This included the option for participants to withdraw from the focus group discussion even when they physically attended it but for any reason had to leave during its course. Although, this did not happen in any of the groups it was planned in advanced (and detailed in the information sheet) that in such a case participants' rights to access, change or remove their information provided up to their participation had to be limited, as the researcher needed to manage their information in specific ways in order for the research to be reliable and accurate. In other words, if any participant withdrew from the study, the information about her/him that was already obtained would have been kept.

- Since all four focus group discussions were conducted within NHS premises, a Research Passport was obtained by the two NHS Health Boards prior to the commencement of the study.
- Material gathered during this research were coded and kept confidentially by the researcher with only the researcher and supervisory team having access. Paper material were securely stored in a locked cabinet and digital material in password protected PC files both within a restricted area of RGU and will be retained for 10 years. Data are stored (i) as per RGU's data protection policy[8] and (ii) separately from identifiable personal information.

6.5.5 Development of topic guide

Two versions of topic guides were developed and used in the focus group discussions: one topic guide was used for the focus group with the infection control teams (Appendix 16A) and another topic guide was used for the focus group with nurses from paediatric hospitals (Appendix 16B). The topic guides included two parts. The two topic guide versions included wording variations (e.g. reference of the concept of IPC in the focus groups with infection control teams and reference of HH in the focus groups with paediatric nurses). Emphasis was placed on starting from participants' own practice worlds so as to encourage contributions. For this reason, part A aimed to investigate the concept of IPC, factors that promote or hinder adherence to hygiene regulations, and the use of visualisations as part of interventions, educational programmes and campaigns. A key consideration in the development of questions in part A was the non-explicit reference to the concept of theory. The decision not to put theory into the first part of questions (but aimed to elicit influencing factors instead) related to starting with aspects with known relevance, given the range of specific and sometimes abstract theories covered in the Delphi study. It is, also, important to note that the concept of theory was brought in the second part of the topic guides. With this in mind, questions related to the factors influencing behaviour were posed instead (this emerged from the Delphi study; see sections 5.5.2.1 and 5.5.3.1). This concept was key in the Delphi

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[8] RGU's data protection policy: https://www3.rgu.ac.uk/about/planning-and-policy/information-governance/data-protection

experts' responses both in the planning and development of interventions but also when considering the type of theory to be adopted.

In part B, a summary of recommendations given by the Delphi experts in healthcare and behaviour change research were presented and discussed with a focus on how theory and visualisations can best be combined. Overall, the topic guide aimed to have a logical flow in the posed questions, by firstly exploring the factors influencing healthcare staff's behaviour in IPC, to how visualisation approaches can aid interventions, strategies and educational programmes, to how these interventions could be more effective leading to sustainable positive outcomes. Finally, exploring participants' perspectives and opinions around the Delphi experts' recommendations (in part B of the topic guide) aimed to identify the acceptability of these recommendations, and the extent to which these converge or diverge from healthcare staff's every day clinical practice. The summary of recommendations was in the form of an outline and acted as a focusing exercise (Bloor et al. 2001; Cyr 2019). This was envisaged to help healthcare staff contextualise and concentrate on a hypothetical behaviour change intervention targeted at their everyday clinical practice.

The topic guides were reviewed and scrutinised by the research team and were piloted with two staff nurses from NHS Grampian. The latter did not take part in the focus group study and came from a non-participating clinical department. The reviewers did not question the readability of the topic guides and found them straightforward and easy to understand with regards to what the focus group was all about and what was expected of the participants. Importantly, the reviewers did not get the impression that the wording was too academic and complicated. The staff nurses positively highlighted that the fact there would be a group discussion which would give participants something to look forward to.

In addition, the topic guides adopted a structured approach with a set of fully worded questions. The questions posed aimed to retain a balance between the focus of the study' aim and the participants' views, perspectives and opinions. Also, the use of the same topic guides across the two types of focus groups ensured a systematic approach a basis for some comparative analysis of findings. For consistency, the exact wording and order of the questions was followed across all focus group discussions. In addition, questions were followed-up by probing questions which were used as and when required to increase the depth and breadth of the discussion. The use of probes aimed to elicit more detail following participants' responses and were of exploratory (i.e., what, how) and explanatory (i.e., why) nature. Examples of such content mining questions were, '*What does anyone else think?*', '*How could these be part of related interventions*?', and '*Is an intervention different from normal practice and why?*'. The use of dichotomous questions (e.g. 'yes' or 'no' questions) and leading questions (e.g. *Is X good for you?*) were avoided.

6.5.6 Recruitment process of participants

The first key step towards the recruitment process of participants was the identification and contact of a gatekeeper across the initially identified and contacted NHS Health Boards. The gatekeepers were individuals who possessed managerial roles and were identified through the websites of each of the relevant focus group sites. For the reasons explained in section 6.2.1 it was decided to conduct the focus group discussion across two Scottish NHS Health Boards. These four gatekeepers were also provided with a copy of the study's research proposal along with the related R&D permission and Research Passport obtained.

Following confirmation by the gatekeepers to assist with the recruitment process, an invitation poster (Appendix 17) was distributed to each of them who were asked to post them up on announcement boards or designated areas within their clinical premises. The gatekeepers were, also, asked to forward the invitation poster by e-mail to healthcare staff or ward managers as appropriate so that to increase the attention given to the study and thus further facilitate the recruitment process. Following the distribution of the invitation posters, healthcare staff across the four focus groups contacted the researcher to express an interest in participating and were then forwarded with a participant information sheet to read and consider.

Although the study successfully received R&D permission within 3 weeks and the systematic communication that was established with the gatekeepers, the recruitment process suffered from a major drawback. This pertained to the fact that many healthcare staff were on annual leave or were about to be on annual leave during the preparation and conduct of the focus group discussions.

Therefore, the gatekeepers' advice was sought as to how to deal with this more effectively. Gatekeepers suggested to send reminder e-mails with the invitation posters to healthcare staff and bring the study to the attention of their colleagues in team meetings as appropriate. In addition, the current researcher met in person with the gatekeepers in one of the participating NHS Trust during the planning of the recruitment process to discuss these issues in more detail.

Taking the above into consideration all focus group discussions were conducted in August 2018. Details about the number of participating healthcare staff in each focus group are presented in the Results section 6.6.2.

At the day of the focus group discussion participants were given the information sheet (Appendix 18) to read again and a consent form (Appendix 19) to read and sign. Copies of both documents were retained by the participants. Participants were reminded that the discussions were digitally audio recorded. Two audio recorders were used for getting clear sound quality. Also, one recorder was used as a backup in case the other went down.

The focus group discussions commenced with an introductory-welcome statement by the researcher ensuring that any questions raised by participants were clarified. Participants were importantly reminded that this was a discussion about their everyday clinical experiences and as such there were no right or wrong answers. All discussions were arranged in a circle seating layout and they were envisaged to last for approximately one hour.

The use of the topic guide at all times facilitated the focus group discussions and was used by the current researcher who also acted as the moderator of the discussions (also referred to as a 'facilitator'). The moderator is the individual leading, and being responsible for organising the focus group discussion, and ensuring that participants do not just talk but engage with each other. In other words, the moderator aims to probe into participants' responses (Pickering and Watts 2005). The role of the moderator in the current focus group was therefore threefold: to set the agenda, to facilitate and steer the discussion and ensure all participants take part in the discussion. After the completion of all questions, the participants were prompted to add any point they wished to or ask any question. The results of the focus group discussions following analysis of the transcripts are presented in section 6.6.3.

6.5.7 Audio recordings

The focus group discussions were digitally audio-recorded using two audio recorders property of the School of Nursing and Midwifery, RGU. Also, during the discussions field notes were taken by the current researcher when appropriate to facilitate understanding of the discussions during the transcription and analysis process. Upon completion of each focus group discussion the audio-recordings were transferred into a password protected PC in a restricted area at RGU. The related files in the audio-recorders were then permanently deleted. These audio-recorded files stored in the PC were accessed and listened only by the current researcher.

The audio-recordings for each focus group discussion were listened through several times for obtaining a better sense, identifying initial patterns and similarities as well as for highlighting areas in the discussion that attracted the researcher's attention. A strict verbatim (word-for-word) transcription of the audio-recordings was followed thus enhancing rigour and validity (Loubere 2017). During the transcription, it was also ensured that participants' quotes were clearly depicted including any verbal or non-verbal aspects of the discussion. The final transcripts were fully anonymous thus not revealing the identity of the participants. A numerical system was used in the transcripts as appropriate to refer to participant responses and quotes (e.g. nurse 1, female; nurse 2, male).

6.5.8 Analysis of transcripts

The transcripts were analysed using thematic analysis following a 6-phase process (Braun and Clarke 2006). This has been described in Chapter 2, section 2.5.4. Familiarisation with the collected data (phase 1) pertains to the researcher becoming familiar with the data, in this case the transcripts from the focus group discussions. This phase began early when the current author was listening to the audio-recordings several times and considering the field notes taken. This approach continued later when transcripts were read systematically and in conjunction with the audio-recordings in order to retain a sense of the spoken and unspoken elements of the discussion including pauses and non-verbal communication (e.g. laugh). This very first step allowed the researcher to immerse himself in the data and take notes of initial thoughts that attracted his attention.

It is key to note that, as part of the data familiarisation and later analysis, the current author aimed to identify and describe themes and sub-themes at the semantic, or explicit, level (Braun and Clarke 2006). However, following the description process, the analysis of themes and sub-themes would progress to the interpretation or latent level where overarching meanings and implications could be drawn

Generating initial codes was included in Phase 2 in an attempt to organise data in a meaningful and systematic way. This included the identification of participants' comments within the transcripts and attributing a code. This was achieved by using a numbering system in the margins beside the text (Ritchie and Spencer 1994). Considering that the analysis was concerned with addressing specific research questions (i.e., theoretical thematic analysis) coding took place for segments of the transcripts that were relevant to or attracted attention regarding the research questions. Having said that, coding was not done line-by-line or covering every piece of text. Also, as the current focus group study involved four focus group discussions, quotes are clearly identified as to what case they came from (e.g. a quote was labelled as 'Nurse 1, female; focus group 1'). An example of coding participants' extracts is given in the table 6.1 below. An extended example of the codes identified for question 1 of the topic guide for both focus group types is presented in Appendix 20.

Table 6.1 Example of indexing participants' extracts

Extract example 1	Code
I think you can use patient line at…you know the television screen that most of the patients have access to within the Children's Hospital. Because the adverts that you drum could be health-related you know if you were allowed you know and if we had enough resources as an NHS funded system, that's not gonna work…but if you could actually… because the children are watching them and if they added television funds…but if there was adverts and they were health-related about washing their hands, brushing your teeth, I think that would be good. (nurse 7, female)	1.1 2.1 2.2 3.1 4.1 1.2 2.3
Extract example 2	**Code**
I think a lot of this is about education because staff should be educated enough to know if a member of staff coughs into the hand they should know to wash the hands. But you'll get parents coming in letting their kids cough-cough-cough or cough into the hands and there's no hand wash…you've got to facilitate it and say you've got to hand gel your hands because you're gonna spread it around. I think it's community education as well. All starts from I don't know where... (nurse 3, female)	1.3 1.3.1 5.1 5.2 6.1 1.3.2

Examples of headings given to codes as presented in the above table 6.1:

1.1 The role of patient line in IPC
1.2 The role of children in IPC
1.3 The role of education in IPC
1.3.1 Staff education
1.3.2 Community education
2.1 Use of TV screen as a visualisation approach
2.2 Use of health-related adverts on TV
2.3 Examples of health-related adverts on TV
3.1 Constraints in intervention implementation
4.1 Limited financial resources
5.1 Knowing when to wash hands
5.2 Parents unaware of when to wash hands
6.1 Act as a role model

The analysis was further facilitated by using NVivo qualitative data analysis software (QSR International Pty Ltd. Version 11 2015). This allowed for organising the large amount of data in the transcripts thus enabling the researcher to make more sense and achieve greater breadth and depth in the analytical process (Maher et al. 2018). NVivo uses the term 'node' to refer to themes (concepts) or people (cases) and the term 'code' to refer to the types of sources that correspond to each node. In other words, node and code refer to the concept of theme and sub-theme. The latter terms, and to be consistent with the terms used in the analysis of the Delphi study (i.e., reference to themes and sub-themes), are used in the following tables depicting the focus group results (see section 6.5). The use of NVivo was also supported by the current researcher's participation at a related training course at RGU obtaining the foundations for using the software effectively.

Following generation of initial codes in phase 2, the analysis continued with searching for themes (phase 3). This was achieved by grouping codes that fitted together into an overarching pattern or in other words a theme. At that phase, preliminary theme names were given and were possible sub-themes were identified and labelled too. The analysis of the focus group discussions was cross-sectional in that themes and sub-themes were identified and compared across the whole data set for each of the two types of focus groups. The use of this approach was envisaged to better mirror the opinions and perspectives of the two types of focus group participants thus allowing to compare and contrast the emerging themes and sub-themes.

Reviewing themes was the focus of phase 4. Following the identification of preliminary themes, the latter were entered into Excel spreadsheets along with the corresponding codes (Bree and Gallagher 2016). This process allowed to determine if the themes made sense in the given context. Also, modifications in the theme names were made as well as regrouping of codes when deemed necessary. In addition, consideration was given to whether there are themes within themes (i.e., sub-themes) and whether the identified themes overlap to some extent with others.

Defining and naming themes in phase 5 included the final refinement of themes. This phase pertained to identifying the 'essence' of individual themes as well as all themes overall and highlighting which participants' extracts each theme captures.

In the final phase 6, the final analysis and writing-up of the report was included. The findings (see section 6.6) are presented narratively in a manner of 'telling the story' and using representative verbatim quotes by participating healthcare staff to portray their opinions and perspectives. By retaining and presenting the original quotes the richness of the data has been ensured (Bowling 2014). Table 6.2 below outlines the 6-phases of the analysis and a short description of the processes involved.

Table. 6.2 Phases of Braun and Clarke's (2006) thematic analysis and description of the related processes

	Phase	Description of processes
1	Familiarisation with data	Narrative preparation by transcribing data; (re-)reading the data and noting down initial ideas
2	Generating initial codes	Coding interesting features of the data in a systematic manner across the entire data set; collating data relevant to each code
3	Searching for themes	Collating codes into potential themes; gathering all data relevant to each potential theme
4	Reviewing themes	Checking if themes relate to the coded extracts; checking if themes relate to the entire data set; reviewing data to search additional themes; generating a thematic map of analysis
5	Defining and naming themes	Ongoing analysis to refine specifics of each themes and the overall story that the analysis tells; generating clear definitions and names for each theme
6	Writing up the report	Selection of vivid and compelling extract examples; final analysis of selected extracts; relating the analysis back to the research questions, objectives and the literature reviewed

6.5.9 Promoting quality in the current focus group study

This section aims to highlight the most important choices and measures taken to ensure the focus group study is sound in terms of methodological decisions. More specifically:

- Although it is recommended to have an assistant moderator to assist with the overall preparation and conduct of focus group discussions (e.g. acting as an extra pair of eyes and taking notes when appropriate) (Krueger and Casey 2014) owing to financial constraints this was not feasible to happen.
- The researcher familiarised himself with literature related to the focus group method to acquire an in depth understanding of conducting focus group discussions and the group dynamics emerging within them.
- Having the current doctoral researcher as the moderator was advantageous due to his in-depth familiarity with the nature of the study. Caution however was required as to minimise any potential moderator bias (Kalu and Bwalya 2017). This was ensured by his self-awareness during the focus group discussions and not expressing personal opinions that could have influenced participants responses.
- The quality of the study was enhanced by the use of audio recorders. This allowed for the transcripts to be verbatim and compared with the audio recordings thus ensuring accuracy of the collected data.
- The quality of the study and thus the doctoral research was enhanced by the decision to conduct two types of focus groups, which was directly informed by the previously conducted Delphi study (i.e., 2 intervention development scenarios: systems-wide and focal). This decision clearly reflected the link between phase 2 and 3 of this research and supported its underpinning methodology (i.e., sequential multi-methods pragmatic inquiry). Importantly, the two types of focus groups involved the recruitment of healthcare staff who shared common characteristics (e.g. academic background, discipline, and professional role) thus being highly homogeneous. The aspect of homogeneity was key in promoting quality in the study

as it enhances group synergy and increases the capacity for group collaboration and confidence building among the participants (Wozniak 2014).

- A systematic and clear decision trail was maintained throughout the study from its conceptualisation to the analysis and writing up stages thus allowing for a rigorous and analytical process to be established.
- The current researcher attended the 'Good Clinical Practice' course (May 2016), 'Good Research Practice (update)' course (April 2018) and ‘Applying for Research Ethics Approval’ module (May 2018) all delivered by NHS Grampian R&D department which offered valuable practical guidance on ethics-related aspects when conducting research.

The key stages as detailed above, and which were involved in the conceptualisation and the conducting of the focus group discussions are schematically represented below in figure 6.1.

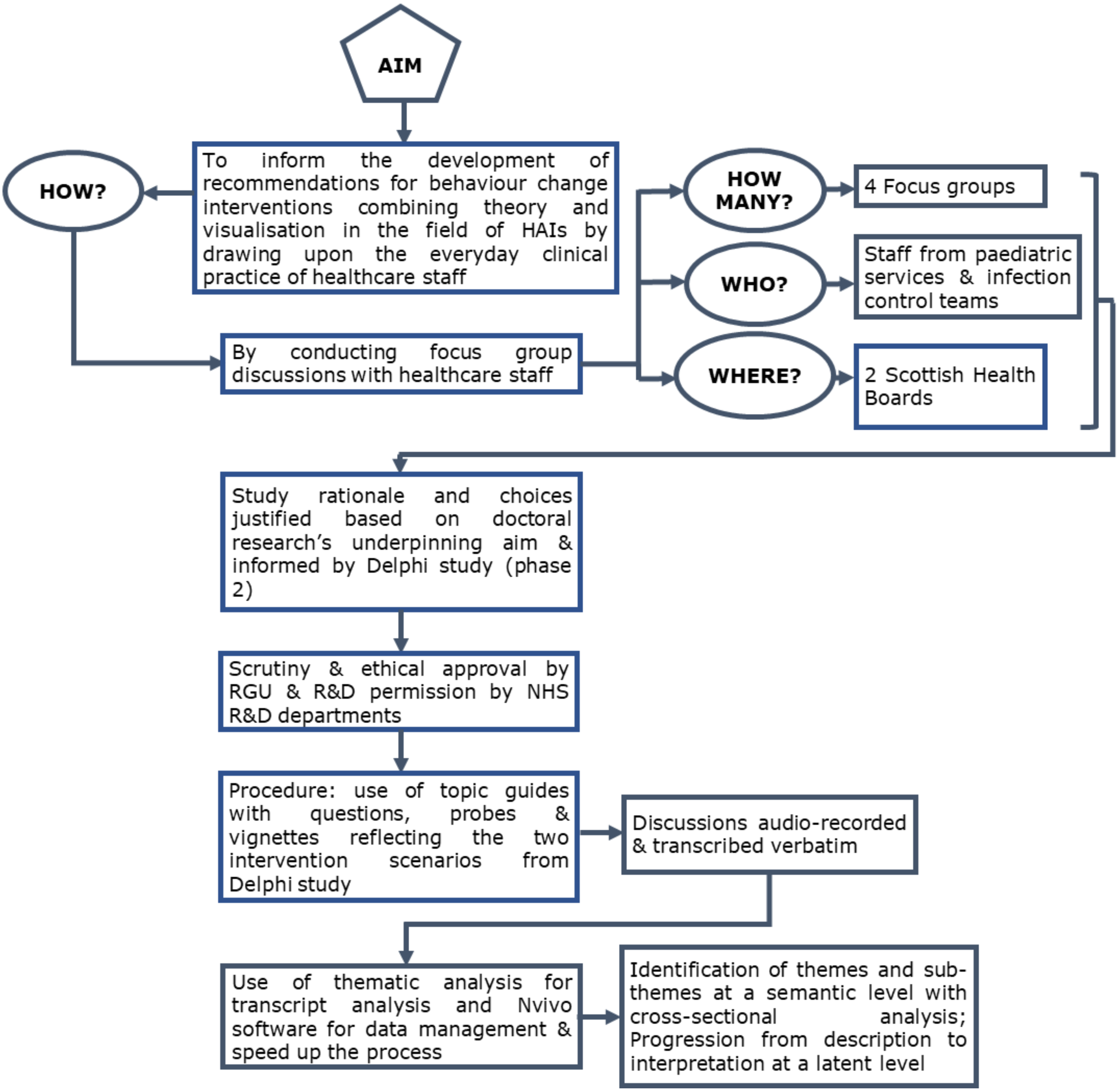

Figure 6.1 Schematic representation of keys stages involved in the conceptualisation and conducting of the focus group discussions

6.6 Findings

Sub-sections 6.6.1 and 6.6.2 pertain to the conduct of the focus group discussions with a focus on aspects of the recruitment process and participants' demographic characteristics. This is followed by the presentation of the main themes and sub-themes identified across the two types of focus groups using verbatim quotes to better reflect healthcare staff's opinions and perspectives. A deductive and interview structure-driven analysis took place.

6.6.1 Aspects of the recruitment process

Despite the recruitment process adhered to a systematic and well-considered plan, challenges emerged in relation to identifying and recruiting healthcare staff. Specifically, as it is presented in section 6.5.1, the intended minimum number of 8 participants in each focus group (resulting in a potential total of 32 participants) was not achieved. In addition, one of the focus group discussions that was initially planned to be conducted in July 2018 was rescheduled as no participants showed up at that day. This led to further liaise with the gatekeeper of that focus group in order to identify an effective action to be taken. The gatekeeper advised to approach individually each unit's manager within the hospital and explore how many healthcare staff from that unit could potentially participate. All managers responded to the author's invitation e-mail and indicated they would be able to 'release' someone on the day of the new focus group discussion. Although, this deviated from the initial recruitment plan according to which interested participants were prompted to get in touch with the researcher, it was deemed as a viable solution for conducting the focus group discussion. This focus group discussion was eventually conducted in August 2018 along with the remaining three discussions. With regards to the duration of the focus groups, this ranged from 45 minutes to 70 minutes (see table 6.3). All of them were informal and relaxing and there were no individuals dominating the discussions. As an observation, healthcare staff who had a considerable experience in their clinical area tended to engage more in the discussions compared to other staff with less years of experience in their post. The researcher adhered to the topic guides across all four focus group using probes to engage participants when appropriate. All participants in each focus group engaged with the questions thus resulting in a natural discussion. Further reflections on these issues are discussed in the Discussion section 6.7.

6.6.2 Demographic characteristics of participants

In total, 18 healthcare staff participated across all four focus group discussions. Five healthcare staff participated in each focus group apart from one where 3 healthcare staff took part. In addition, healthcare staff came predominantly from a nursing background and only one from a podiatry background. In terms of gender, participants were predominantly female (16 out of 18). Furthermore, with regards to their professional role, participants in the IPC teams were either IPC nurses, senior IPC nurses or a HH co-ordinator. In the focus groups conducted in paediatric hospitals, participants were staff nurses or educator. Also, the latter were based at various departments within the paediatric hospital including the oncology department, paediatric ICU, the emergency care unit, the surgical department, the neonatal unit and medical department. Finally, regarding the participants' years in their post these ranged from 1 month to 30 years. The above demographic characteristics of participating healthcare staff are shown in table 6.3 below. The order of the focus groups and their participants' characteristics as shown in the table represents the actual order in which they have been conducted.

Table 6.3 Characteristics of participating healthcare staff in relation to their sex, discipline, professional role and years in post across the four focus group discussions (abbreviations used are explained at the end of the table)*

	Participant	Gender	Discipline	Professional role	Department	Years in post	Duration
Location1 IPC team	1	F	Nursing	IPCN	IPC team	1 month	75 minutes
	2	M	Nursing	IPCN	IPC team	3 years	
	3	F	Nursing	IPCN	IPC team	3 years	
	4	F	Nursing	IPCN	IPC team	4 years	
	5	F	Nursing	ICPN	IPC team	2 months	
Location 2 Nurses from paed. services	6	F	Nursing	Staff nurse	Oncology	4 years	50 minutes
	7	F	Nursing	Staff nurse	Paediatric ICU	5 years	
	8	F	Nursing	Educator	Neonatal unit	2 years	
Location 3 Nurses from paed. services	9	F	Nursing	Staff nurse	Surgical	30 years	50 minutes
	10	F	Nursing	Staff nurse	*Not indicated*	2 years	
	11	F	Nursing	Staff nurse	Emergency care unit	17 years	
	12	F	Nursing	Staff nurse	Emergency care unit	12 years	
	13	F	Nursing	Staff nurse	Medical	5 years	

Table 6.3 *Continued from previous page*

	Participant	Sex	Discipline	Professional role	Department	Years in post	Duration
Location 4 IPC team	14	F	Nursing	SIPCN	IPC team	8 years	55 minutes
	15	F	Nursing	SIPCN	IPC team	14 years	
	16	F	Nursing	SIPCN	IPC team	1 year	
	17	F	Nursing	SIPCN	IPC team	3 years	
	18	M	Podiatry	HH co-ordinator	IPC team	11 years	

*Explanation of abbreviations: F: female, M: male, IPCN: infection prevention & control nurse; ICU: intensive care unit; SIPCN: senior infection prevention & control nurse

6.6.3 Themes and sub-themes

The identification of themes was determined by the nature of questions in the topic guides used with the emergent sub-themes reflecting participants responses. Each theme and its corresponding sub-themes are presented separately for both types of focus groups (i.e., healthcare staff from infection control teams and nurses from paediatric services) in the following sub-sections. Illustrative quote examples by participants are provided where necessary to better reflect the identified themes and sub-themes.

6.6.3.1 Themes and sub-themes from IPC teams

The 6 main themes identified in the focus groups with the infection control teams are: use of IPC policies, factors influencing IPC practice, IPC interventions seen as multifaceted, a multi-stage adoption of visualisation in IPC, intervention success through 'buying-in' and practical challenges in applying Delphi recommendations. These themes and their sub-themes are shown in figure 6.2.

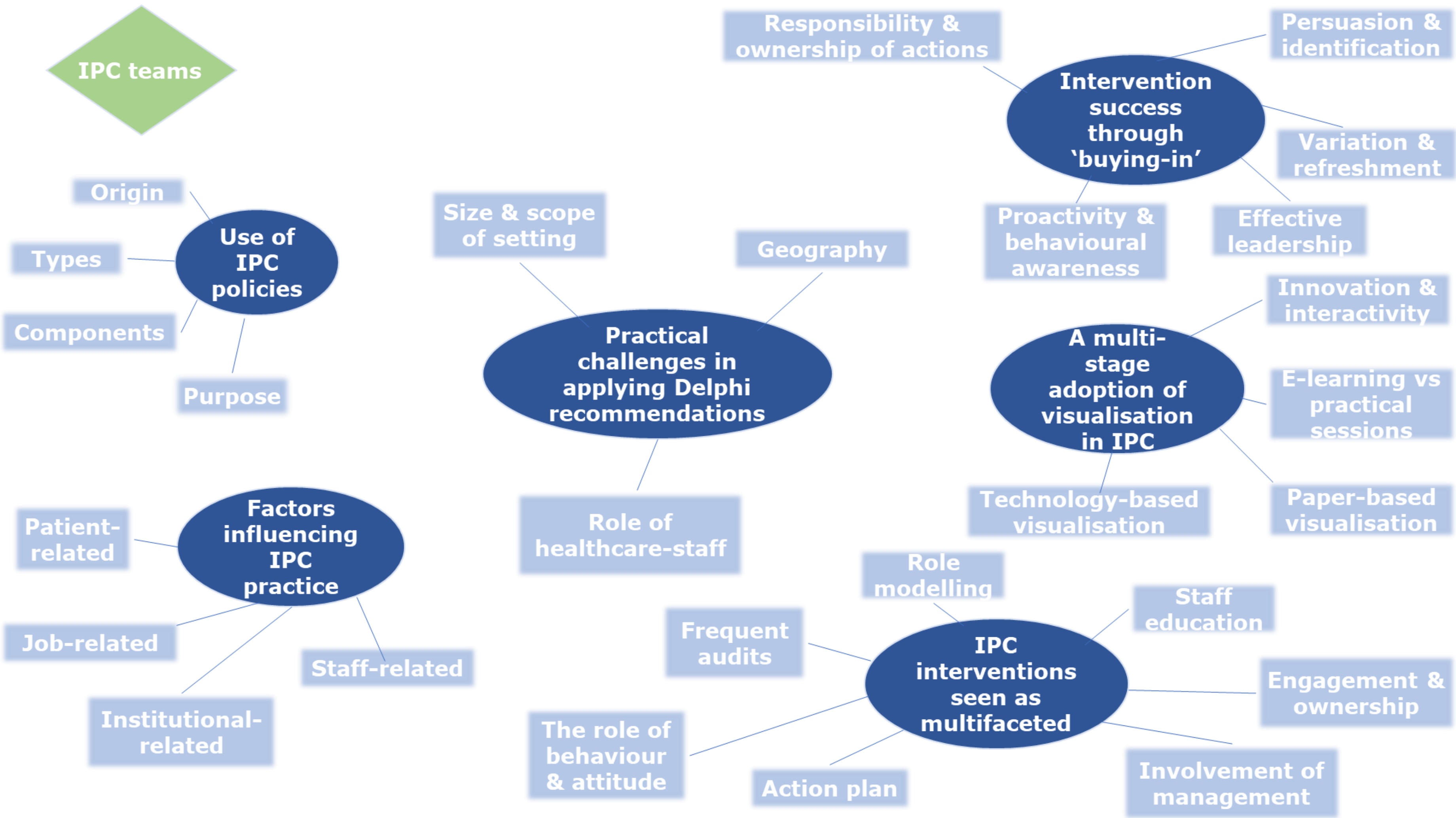

Figure 6.2. Thematic map showing 6 main themes and their sub-themes for the infection control teams

6.6.3.1.1 Use of IPC policies

Within the thematic area of the use of IPC policies, sub-themes pertained to their origin, types, purpose and components.

Sub-theme: Origin

In relation to the origin of IPC policies, these were either local/unit-based, national or international. For example, a participant explained that,

> *"Our policies are based on guidance we receive from Health Protection Scotland. We have a national manual that contains guidance and we then develop our own local policies and we call them 'Standard Operating Procedures'. That relates to the Standard Infection Control Precautions or Enhanced Precautions in addition which we call 'transmission-based precautions', so that's where our local policies are held and an online manual that staff can access but is based on the wider national guidance that we receive from Health Protection Scotland."* (nurse 15, female)

Sub-theme: Types

In relation to the types of IPC policies currently in use, participants noted that these are HH-, and HAIs-related. A participant said that,

> *"A lot of our policies are from Health Protection Scotland, but in regards to HH there is a local HH policy which is for the role of [name of Health Board]."* (nurse 1, female).

And another participant said,

> *"You've got your … for example C. difficile policy updating that and is based around Health Protection Scotland's policy for C. difficile."* (nurse 2, male)

Sub-theme: Purpose

The sub-theme of policy purpose was mirrored on participants' responses in relation to educating and training healthcare staff. One participant said,

> *"So that's what we can educate staff and then we do…from that policy we go out onto the wards and we do what we call 'cascade training' so then we train them to be trainers as well, so they can do their own HH audits."* (nurse 1, female)

The above quote, also, reveals the facilitatory role of infection control teams who do not just aim to intervene and suggest specific actions towards proper IPC practice, but importantly strive to empower healthcare staff.

Sub-theme: Components

Finally, some of the components of IPC policies were highlighted by participants. One of them noted that,

> *"So the 5 Moments, the technique we use, the 6-step technique so we have taken that…essentially again it's came … a national infection prevention and control manual … so we left a lot of their policies and guidance … but yeah the 5 Moments for HH we've taken directly."* (nurse 2, male)

6.6.3.1.2 Factors influencing IPC practice

With regards to the factors influencing IPC practice, participants from the infection control teams highlighted that these factors are predominantly staff-related, patient-related, job-related and institutional-related.

Sub-theme: Staff-related factors

In relation to staff-related factors, a participant explained that owing to staffing issues healthcare staff have to take shortcuts thus impacting on IPC practice, *"I agree … part of what you said on your first point G. … it's staffing as well. They don't have enough staff so they take shortcuts, so like G. said they may not intend to not adhere to policy but they have to take shortcuts because of time restraints and pressures."* (nurse 3, female)

and another further explained that healthcare staff's behaviour including attitudes and beliefs can positively influence IPC practice,

"I think that things that would positively influence them would be again behaviours, and attitudes and beliefs … so again if you've got people that are understanding infection control and who have an interest in it they will push forward that in a way that ties in the busyness of the wards." (nurse 4, female)

The above examples reveal that healthcare staff have to cope with competing priorities in their everyday clinical practice. On one hand, they appreciate the importance of IPC practice and recognise they have to prioritise patient care but this seems to be 'sabotaged' by logistical challenges which are inherent in their job. Such hindrances seem to affect specifically doctors who appear to be less compliant to IPC practices during audits. As an infection control nurse suggested, medical staff embrace the presence of research evidence for performing IPC practices and when such evidence is absent then doctors are more likely to be less or non-compliant,

"You will hear a lot in the wards that the senior charge nurses of the wards get quite frustrated because doctors are included in their ward audits and a lot of the time, not all the time, but a lot of the time is doctors that's been the cause of low compliance and they get quite frustrated. I think the difference between nursing and medical staff is that medical staff like everything to be evidence-based and they'll question it. And if they can't see the justification for doing something, they wouldn't do it. They've got the confidence to say 'I am not doing it'. Whereas nursing staff are generally lot more … ok. They will not question it. They'll just go ahead and say 'alright I have to do this, I will do it'." (nurse 4, female)

Sub-theme: patient-related factors

With regards to patient-related factors, increased pressures and demands can give rise owing to the ageing patient population and thus impact on IPC practice. Specifically, a participant mentioned that,

> *"[…] but because of the pressures and the demands on ageing population we've got a lot of patients that we've seen in the past so I think the demands that are put on staff are logistically what they're prioritising."* (nurse 16, female).

Sub-theme: Job-related factors

Job-related factors pertained to the busyness of the wards and time constraints. As a result of these factors, a participant explained that infection control is often seen as an 'add on' rather than embedded in daily practice,

> *"Time factors and the busyness in the wards … they're [reference to healthcare staff] prioritising patient care and moving through and sometimes they see infection control as an add on rather than embedded as part of the day to day work so I would definitely say time factor and busyness of the wards as one."* (nurse 16, female).

Sub-theme: Institutional-related factors

Finally, institutional-related factors were mentioned as key to influencing IPC practice. One of these is the extra paperwork, which is seen as a hindrance to infection control,

> *"I think they see it as a hindrance, all the extra paperwork they've got to fill out as you say there's more like and added extra … I don't think they've got the understanding or just to … you know it doesn't tie up you've got to follow these procedures like to prevent harm to the patients and I think they generally don't understand it."* (nurse 17, female)

6.6.3.1.3 IPC interventions seen as multifaceted

Participants from the infection control teams felt that that the adopted IPC interventions are holistic in nature. Specifically, the multifaceted range of tasks that infection control teams are undertaking across the whole healthcare organisation (e.g. in terms of auditing, training, intervening, educating etc.) was reflective on how infection control teams see IPC interventions. Importantly, the interventionist nature of infection control teams as regarded by the team members was evident. The multifaceted scope of IPC interventions was mirrored, also, on the identified sub-themes: role modelling, frequent audits, the role of behaviour and attitude, action plan, staff education, staff's engagement in and ownership of IPC practice and the involvement of management.

Sub-theme: Role modelling

The multifaceted character of IPC interventions is reflected by infection control participants suggesting that role modelling is not only restricted to infection control staff but should underpin all healthcare staff's practice,

> **"***Well, a consultant has no intention to take part in any 5 Moments while we're standing them and watching them. So, it's role modelling, it's the example. As much as we go out to the ward and we do role model … it's not just down to us, it's down to as I said people taking ownership."* (nurse 2, male)

Sub-theme: Frequent audits

The 'interventionist' character of infection control teams was, also, mirrored on the sub-theme of frequent audits,

> *"From my experience doing observational audits of staff [is regarded as an intervention] I would speak about their practice based on that so if I see something that is either going well or not going quite so well I would speak to the staff afterwards and I would also speak to the management to make sure that they are reinforcing the message of what we've seen*." (podiatrist 18, male).

The physical presence of the infection control team members was stated as another way of intervening. A senior infection control nurse said that,

> *"I think an intervention can be something as simple as you are on the ward and you see someone coming out of the ward if they haven't washed their hands, they haven't taken a PPE on and just say to them "excuse me, can you … ?" and explain them why they should be doing something. And then maybe it gets more to them if you notice something happening all the time, maybe go to the stage to have a meeting with the management and put an education."* (nurse 14, female).

Sub-theme: Role of behaviour and attitude

Participants, also, recognised the importance of aspects endogenous to the individual as is behaviour and attitudes. One participant noted,

> *"I think the things that would positively influence IPC practice would be behaviours, and attitudes and beliefs … so again if you've got people that are understanding infection control and who have an interest in it they will push forward that in a way that ties in the busyness of the wards."* (nurse 15, female)

Sub-theme: Action plan

Adhering to an action plan was another aspect recognised as being inherent to IPC interventions.

> *"You might class a moment I should class as a moment and vice versa not just kind of based on a personal opinion … this is actually what you look for. In this basis, in the wards it is expected to follow … there is a flow chart and they will be expected to follow that flow chart just as we do if we've done it. And that flow chart says if it's a 90%, they've got to do a local action plan and re-audit."* (nurse 14, female)

Sub-theme: Staff education

Regarding the sub-theme of staff education, infection control teams highlighted the importance of identifying any educational needs of staff and take the necessary actions to support them,

> "*I see education as an intervention when we recognise educational needs of staff in a particular area where we try to intervene and provide education where it can be ad hoc or an arranged programme of education*." (nurse 17, female)

Sub-theme: Staff's engagement in and ownership of IPC practice

The fact that the promotion is not just the 'responsibility' of the infection control team is highlighted in the following sub-theme and related quote example. Specifically, healthcare-staff engaging in, and taking ownership of their IPC practices was, also, highlighted as key in pertinent interventions thus denoting that infection control teams are facilitating rather than interfering with staff's IPC practice,

> "*People need to take ownership of their own learning, their own areas, their own improvements we can come in and guide them a lot but it's not us that needs to … we're here to help you, we're not here to sort you."* (nurse 2, male)

Sub-theme: Involvement of management

The key role of management to reinforce the infection control team's messages was highlighted,

> *"I would also speak to the management to make sure that they are reinforcing the message of what we've seen so … a lot of what we do is compliance audits to make sure that staff are doing what they should be doing so that is what I generally see as an intervention. The discussion with staff."* (podiatrist 18, male).

The above example, highlights that an inclusive approach in IPC interventions is needed where the management can make an active contribution and facilitation of IPC practice.

6.6.3.1.4 A multi-stage adoption of visualisation in IPC

Another pattern found was the multi-stage adoption of visualisation in IPC. This reflected the range of visualisation approaches adopted by the infection control teams, and stages involved thus denoting the importance of using visualisations to facilitate IPC practice. The sub-themes identified are: paper-based visualisation, technology-based visualisation, e-Learning vs practical sessions, and innovation and interactivity.

Sub-theme: Paper-based visualisation

Paper-based visualisation approaches are widely used in IPC practice, however their appropriateness was brought into question,

> *"From a HH point of view, there has been different stages. There were lots of posters, leaflets, there was press works there was a lot of work done with the media as well to highlight the 5 moments, the 6-step technique. We adopted that over the years, when we first started there was quite … it was a soft approach. There was a poster showing a hand giving a plate, someone pushing a wheel-chair. But after a few years the feedback we were getting was that they were not getting the message across, so we moved to a black background to make it more stark."* (podiatrist 18, male)

Another participant referring to the use of posters said,

> *"There's quite a lot of visual posters but the problem with that is that is white noise."* (nurse 2, male).

Another participant noted that the long display of posters may make visualisation background noise although she positively commented on the use of visual posters showing the consequences of non-compliance,

> *"I do like visual aids for showing staff what could happen if they don't comply. I think they can be a good aid for certain things. But then at the same time if there is something on display for a great length of time it just becomes background noise. It's just there*." (nurse 15, female)

The interpretation of the above example is twofold. Firstly, it suggests that the aspect of providing feedback on behaviour and its consequences (in this case non-compliance with IPC practice) can render static forms of visualisation (as in the case of paper-based visualisations) more meaningful and potentially impactful. Secondly, it suggests that paper-based visualisation approaches in particular need to be refreshed and not be displayed for a long period of time as this may lead to no positive outcomes.

Sub-theme: Technology-based visualisation

The use of technology-based visualisation approaches was also discussed. Despite their impact as well as acceptance and positive feedback by the healthcare staff the infection control teams noted that these approaches are usually expensive and are turned down,

> *"We have trials of technology: sensor operated, a voice message or you have flashing lights to show where the HH stations are. The main problem we generally find with them and although we get good feedback from the staff about them, is the cost is usually prohibitive. So, if you can get some piece of technology but it is going to cost you the cost of hiring a member of staff for a year there is no question, they are going to hire a staff. They will not pay for the technology. It can be frustrating because we know it can have an impact. The public tend to respond to these things very well. They like to see more technology, more visual things that stand out basically."* (nurse 2, male)

Sub-theme: e-Learning vs practical sessions

The infection control teams, also, discussed the value of both e-Learning (e.g. online modules) and practical sessions (e.g. use of glitter and UV light to depict the spread of pathogens) as visualisation approaches. Participants suggested that e-Learning lacks interaction compared to practical sessions. On the other hand, busy healthcare staff can use e-Learning remotely as opposed to practical sessions which can be challenging in terms of time constraints. A participant mentioned that,

> *"We've got basic practical things but as e-Learning is taking over that, that interaction. I guess with the team as well as with infection control … it has been taking over by e-Learning stuff. And there's a lot of things with infection control you need to see practically to be able to say this is what you need to prevent."* (nurse 2, male)

And another one said,

> *"I much prefer actually to being you on e-learning. Because if someone has got a question at least they can ask us because we're there rather than if it is e-leaning it might be "Ooh, I must remember, I have to give them a call to get my question answered". But the difficulty with people in practical sessions again is time."* (nurse 4, female)

Sub-theme: Innovation and interactivity

Innovation and interactivity comprised the fourth sub-theme. Participants suggested that the dryness of mere infection control education can be substituted with simple but innovative and interactive approaches. For example, a participant said,

> *"This is not a trial, it's gonna be like fun little bite-size education. So we're gonna be getting like little fluffy micro-organisms and they're gonna have to put the posters and you're gonna have to say what is an MRSA and stuff like this … and empty*

antibiotics boxes and they are going to put them on the right cart… just try and make it fun. You're working at that side today, you're working at that side today, you're gonna check drug prescription chart, see how many years he has been prescribed correctly and come back. They've been split into teams so they're quite keen." (nurse 1, female)

The above example suggests that even simple and relatively cheap visualisation-based approaches can be adopted by infection control teams and potentially be impactful in IPC practice.

6.6.3.1.5 Intervention success through 'buying-in'

The concept of 'buying-in' was identified as key for an IPC intervention to be effective and lead to sustainable effects over time. Specifically, the success of IPC interventions was found to come through healthcare staff, management/leadership as well as the characteristics of interventions as suggested by the five related sub-themes namely, taking responsibility and ownership of actions, proactivity and behavioural awareness, persuasion and identification of healthcare staff, effective leadership, and variation and refreshment of interventions.

Sub-theme: Taking responsibility and ownership of actions

In relation to healthcare staff taking the responsibility and ownership of their actions was highlighted by a participant,

"There is one Board who they were having quite a lot of issues with their invasive device maintenance and senior charge nurses there along with support from other colleagues took a very proactive approach a certain approach, but a receptive approach as well; and she allocated staff each day, discuss it every morning and she still continues to do that and then their compliance rates went soaring. And that was the constant saying. It's just your responsibility to do it, you do it this morning you don't have an

excuse you just do it and then just remind them every day. It took a few months and that worked." (nurse 1, female)

The above example highlights that when the concepts of responsibility and ownership of one's own actions are systematically embedded in everyday clinical practice, they end up as being habitual and a hard-wired part of IPC practice.

Sub-theme: Proactivity and behavioural awareness

Healthcare staff being proactive and having awareness of their behaviours were seen as two important aspects for an IPC intervention to be effective. With regard to this sub-theme a participant said,

> *"People might not be so receptive to it as somewhere else. It's people having behavioural awareness and nobody comes to work to make a mistake and nobody doesn't go to be aware of things he shouldn't be doing properly."* (nurse 2, male)

Sub-theme: Persuasion and identification of healthcare staff

For an IPC intervention to succeed, participants suggested that it is not a matter of merely providing information about optimal practice and related behaviours. Its persuasion and identification that are key,

> *"I think people have got to buy in the strategy. If they don't buy it in your strategy is going to fail. As much as… it might work somewhere, it might not work somewhere else.* (nurse 3, female)

Sub-theme: Effective leadership

In relation to the sub-theme of effective leadership, a participant noted that,

> *"I guess it's the senior charge nurses taking charge of a situation."* (nurse 2, male)

And another one continued,

"They're also letting the staff know that you are accountable. This is not just me as a charge nurse, you are accountable. It's the effective leadership." (nurse 3, female)

Sub-theme: Variation and refreshment

With regards to the characteristics of interventions, a participant highlighted it is important to have multicomponent interventions with variation and refreshment,

"I think it has to be a programme, having different things so staff never get used to them. So, we have posters and change them after 6 six weeks. And then you can try something electronic. It is constantly changing." (podiatrist 18, male)

6.6.3.1.6 Challenges in applying Delphi recommendations

Healthcare staff from the infection control teams reacted positively to the recommendations by the Delphi key experts presented in the form of a summary of key points. A participant said,

"Yeah, they sound very sensible." (nurse 1, female).

They particularly embraced the concept of co-design and the key role of healthcare staff in intervention development stating that,

"Yeah, absolutely. And I think definitely co-design … because again it's not us that we can develop an intervention but how does the ward, the clinical area, the person understand that. How to fit to them or apply to them." (nurse 2, male).

Participants did raise, however, concerns as to the feasibility of key experts' recommendations and the challenges of applying these recommendations in practice. Such challenges related to three sub-themes namely, the different professional roles of healthcare involved in IPC interventions, the size and scope of the healthcare setting and the aspect of geography of the setting and Health Board.

Sub-theme: Different professional roles of healthcare involved in IPC interventions

In relation to the sub-theme of healthcare staff's professional roles the practical challenge related to how feasible it is to speak to and involve the right people,

> *"In some places, like the community hospitals you could* [i.e., implement Delphi recommendations] *and in* [name of Health Board] *there would be one manager you would be talking to, a key sector you might talking to the senior charge nurse, talking to the nurse manager, chief nurse maybe talking to the wrong people it's people actually going to be implementing it and using it and dealing with it and you want their opinions … it's not your management structure their opinions are valuable as well. But it's the people who are actually going to be dealing with it. Quite often it's only the management who is sitting around the table discussing it. Whereas there should be the people who have to work."* (nurse 2, male)"

Sub-theme: Geography

Another key challenge expressed by one of the infection control teams was related to geographical constraints,

> *"I guess the challenges we face here* at [name of Health Board] *are different from the challenges they face in* [name of Health Board] *or somewhere else. Our biggest challenge is the geography of it. It's not just here, it's the greatest 100 miles. It's a community hospital 50 miles north of here."* (nurse 2, male).

Sub-theme: Size and scope of setting

The size and scope of the healthcare setting was also seen as challenge to implementing the Delphi experts' recommendations,

> *"I think it is a good idea to take everybody's ideas on board but in [name of Health Board] I don't know how easy will be to do. It is ideal, it does work but just replicating it on a grand scale would be difficult."* (nurse 4, female).

This was further corroborated by another participant who highlighted the impact visualisation approaches in IPC can have and the inherent constraints imposed by facilities-related national guidance,

> *"It is very impactful when you can visually show people either through video or real time looking at a scenario-based environment. I think the difficulty comes when you're talking about say the ward setting, the ward layout making that more conducive to getting staff to do the behaviours that becomes difficult when your design of that area is constrained by health facilities Scotland guidance which has good infection control, you know, evidence to back up why healthcare environment has to be in a particular layout so you've got competing factors there to adhere to the guidance."* (nurse 17, female).

6.6.3.2 Themes and sub-themes from paediatric services nurses

The 6 main themes identified in the focus groups with nurses from paediatric services are: use of HH policies, factors influencing HH, interventions in the context of individual HH behaviour, need for visualisation to address challenges in clinical practice, assimilating HH behaviour for intervention success and need for healthcare staff to be given voice in the decision and policy process. These themes and their sub-themes are shown in figure 6.3.

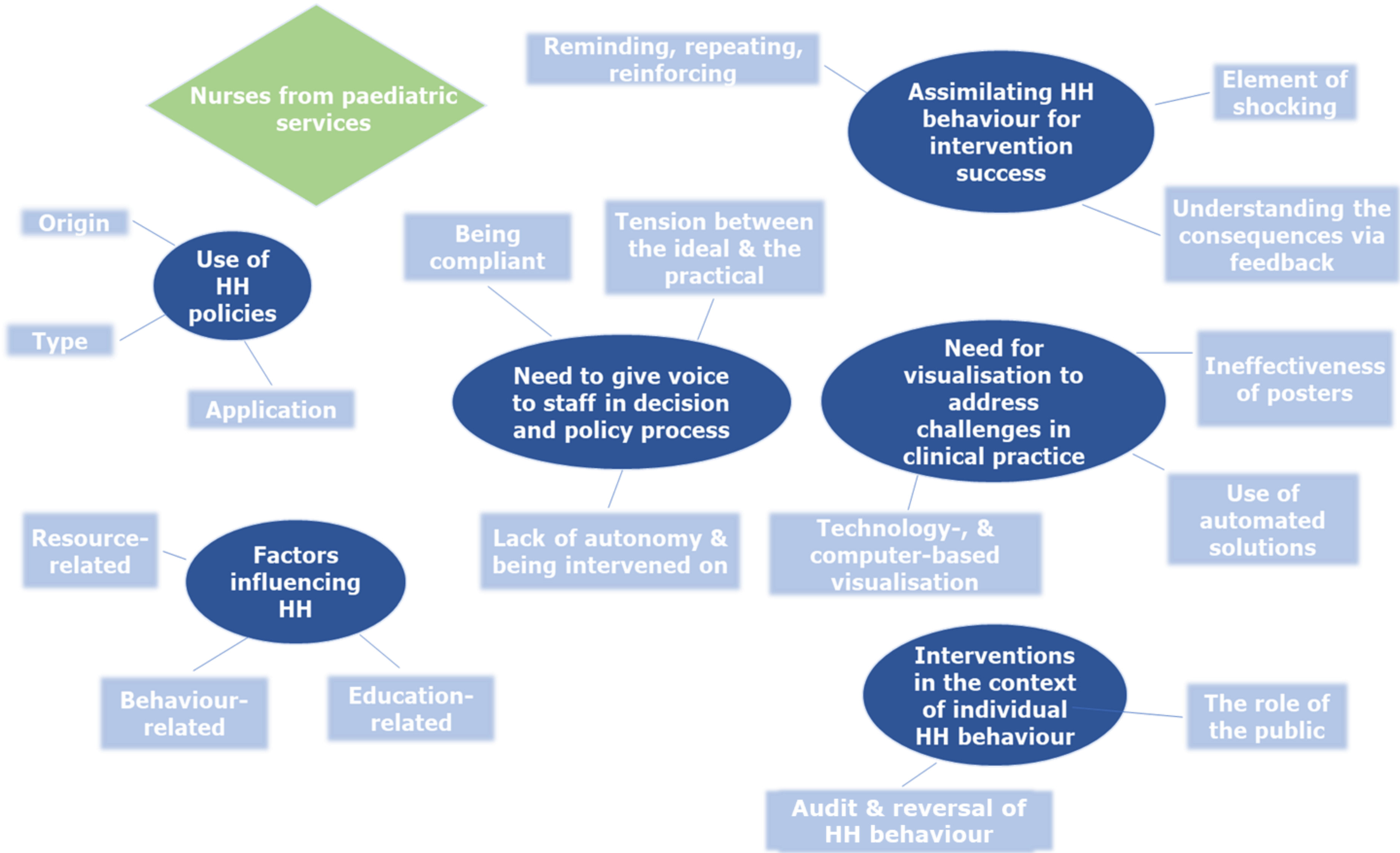

Figure 6.3. Thematic map showing 6 main themes and their sub-themes from paediatric nurses

6.6.3.2.1 Use of HH policies

The theme of use of HH policies comprised of three sub-themes namely, origin, type, and application. Nurses explained that HH policies may be of different origin (e.g. policy of the Trust), different types with reference to HH (e.g. My 5 moments of HH) and application.

Sub-theme: Origin

Paediatric nurses explained that HH policies used have a national and local origin. For example, a nurse said,

> "*Which is part of the* [Name of NHS Health Board] *health policy* [reference to 5 moments of HH]." (nurse 13, female)

Sub-theme: Type

With regard to the type of HH policies, participants unanimously mentioned using the 5 Moments of HH,

> *"Like the 5 Moments of HH … I think we do that all the time…well we certainly do in ECU … because we're in and out of the rooms all the time, we're seeing patients all the time so we do HH quite a lot…using that 5 Moments of HH."* (nurse 11, female)

Sub-theme: Application

With regards to the application of HH policies nurses suggested that these policies are primarily unit-specific. For example, a participant said,

> *"Within [Name of Health Board] they have policy for washing within our unit … that's specific about when you should wash your hands."* (nurse 16, female)

Based on the responses of both the nurses from paediatric services as well as the infection control teams, it is evident that specific policies are implemented across the different areas of the hospital. Importantly, healthcare staff have an understanding of how and why their IPC-related practice is governed.

6.6.3.2.2 Factors influencing HH

Nurses, also, highlighted specific factors that influence their adherence to policies and thus HH practice. These factors pertained to resources, education and behaviour.

Sub-theme: Resources

A characteristic example of resource-related factors was given by participants in relation to lack of sinks and hand gels,

> *"Resources … you know we're supposed to gel our hands you know or wash your hands depending on the circumstances. And we don't always have handwashing sink available we don't always have gel available."* (nurse 11, female)

Within the sub-theme of resource-related factors, participants also talked about the issue of skin irritation as a result of the soap they use,

> *"The soap as well. It's a very harsh soap for your skin. So, your skin breaks down quite easily because of the frequency that you have to wash your hands. They came over here to change the soap we used to do and there was a change in the skin integrity of our hands."* (nurse 8, female)

Sub-theme: Education

Education was acknowledged as another factor influencing HH and was deemed important especially for healthcare staff with many years at their post and in relation to practice that has changed over the decades,

> *"Sometimes, is because for me being here for 30 years, you know practices have changed greatly so you need to keep*

me up to date for me to then change practice and improve practice. So, we don't … I don't think we get an awful lot of education." (nurse 9, female)

A further interpretation of the above example reveals the 'interventionee' mindset of healthcare staff in a sense that they are expecting some form of intervention or training to facilitate their clinical practice. In other words, they often present themselves as recipients of interventions that seem done to them.

Sub-theme: Behaviour

The concept of behaviour was another factor influencing HH and pertained to the actual frequency of handwashing and the need to dry hands properly. With regards to the frequency of handwashing a participant said,

> *"We're probably OCD about washing our hands. I am worried I personally make the patients sick by not washing the hands. The techniques we're doing are correct, but I think for having so many line infections, for having children so sick in front of you I think we should wash our hands countless times every day."* (nurse 7, female)

The above example highlights the prioritisation that healthcare staff give to patient care. Specifically, it suggests that healthcare staff are worried about making their patients sick as a direct result of their HH practice and despite the fact that frequent use of harsh soap will most probably lead to breaking down their hands. However, paediatric nurses as in the case of infection control teams explained that doctors appear to be less compliant with hygiene policies thus suggesting a suboptimal HH behaviour. For example, a nurse indicated,

> *"It's really your nursing training. I think nurses get top more how to wash your hands like doctors do like my experience is that more often doctors actually do not wash their hands or as long as they should do or appropriately so. I think sometimes it's the lack of training, not in the nursing side."* (nurse 7, female)

6.6.3.2.3 Interventions in the context of individuals HH behaviour

Within the theme of interventions in the context of individual HH behaviour paediatric nurses experienced interventions as specific and instrumental in nature. Specifically, two sub-themes were identified namely, audit and reversal of behaviour and the role of the public.

Sub-theme: Audit and reversal of behaviour

With regards to the sub-theme of audit and reversal of behaviour participants explained that audits are perceived by them as a form of intervention which can be impactful. This impact, however, appears not to be sustained as healthcare staff revert back to their 'old ways' as soon as the audit process is completed,

> "*The most effective way would be when it comes to an audit … cause you do … you can't stand on the floor all day long like every single day. As soon as this is away people revert back to their old ways*." (nurse 8, female)

The above quote example, apart from highlighting the importance of audits in the context of HH and thus IPC practice it raises the issue of sustainability of behaviour which has been key in the current study as well as doctoral research overall.

Sub-theme: Role of the public

The second sub-theme that emerged related to the key role of the public in the context of HH behaviour. Specifically, participants provided the example of patients' parents positively influencing staff's HH practice,

> "*I think as well, the parents in my ward are absolutely wired to the moon. So, if you don't wash your hands they will say to you "you haven't washed your hands" cause you're so fixy trying to keep the tale walk free they'll pull you up and wash your hands so I guess that probably helps to wash your hands because they're constantly at your back making sure*

> *they're watching you. You know they're watching you to make sure"* (nurse 7, female)

As another participant aptly noted that parents become auditors, it appears this is both welcome and helpful towards HH practice despite the more challenging and stressful it can render staff's clinical practice. Healthcare staff's receptiveness to parents' unintentional contribution may indicate that the public (e.g. patients' parent and other relatives) have a key role to play in pertinent interventions within the HH and IPC context.

6.6.3.2.4 Need for visualisation to address challenges in clinical practice

Participating nurses described various forms of visualisation approaches in light of addressing challenges in their clinical practice. Within this theme, three sub-themes pertained to technology-, and computer-based visualisation, automated solutions and the ineffectiveness of posters.

Sub-theme: Technology-, and computer-based visualisation

In relation to technology-, and computer-based visualisation approaches participants outlined a range of traditional (e.g. use of light box, videos with HH content shown on hospital's tv screens) and less traditional approaches (e.g. use of e-Learning courses and online modules, device for virtual hand washing) used primarily for learning and induction purposes. For example, a nurse said,

> *"I remember when I did my induction back a long time ago we were washing our hands in that box with the light. And you were putting your hands in. You were washing your hands and then put your hands in and you could see the dirt, visually ooh my God."* (nurse 6, female).

Nurses, also, expressed some ideas regarding promoting hygiene using visualisation approaches and resources already in place. One of them said,

> *"I think you can use patient line at the television screen that most of the patients have access to within the Children's Hospital. Because the adverts that you drum could be health-*

related you know if you were allowed you know and if we had enough resources as an NHS funded system, that's not gonna work. If there was adverts and they were health-related about washing their hands, brushing your teeth, I think that would be good." (nurse 7, female).

Within the current sub-theme participants suggested that e-Learning may not be helpful owning to the fact that the content of online modules is not refreshing, and staff know already the answers. For example, a nurse said,

> *"The difficulty with them I think now having done the same online module for several years is it's a bit tedious, they haven't changed it, you've got your background knowledge, you understand the process but not giving me any further information so they're not training me any further. It's the same training material for the last at least 3-4 years. To be honest some staff don't actually watch the whole of the e-Learning programme and go through the whole of the process because they know the questions, they know what the module contains and they can answer the questions directly. So, I don't think that the e-Learning training and the visualisation from that is particularly helpful for some staff." (nurse 11, female)*

The latter quote example is in concordance with the infection control teams who also questioned the effectiveness of e-Learning as a visualisation approach in IPC. For the reasons described by participants, this may underscore the need for staff to be kept up-to-date and for refreshing the content of online material periodically so that staff do not "skip" its learning sections nor regard it as "boring" or "tedious". It, also, reveals the 'interventionee' mindset of paediatric nurses as they feel they are not given any further information nor receiving any extra training as they would expect. Also, the former quote example suggests that traditional and relatively low-cost visualisation approaches can attract staff's attention and can be well received by them.

Sub-theme: Automated solutions

Regarding the sub-theme of automated solutions, participants talked about the concept of automatization in HH and provided a related example which staff were aware of but not engaged with it in their practice (i.e., it was not applied in their clinical setting),

> *"I don't know if you ever had automatic taps that caught out after 15 seconds, so you knew that's how long you were supposed to wash your hands for … if someone walked away and they weren't… the tap was still on you got like you haven't washed your hands for long enough…and then people were … "ooh I understand it I need to wash my hands"."* (nurse 8, female).

Although, nurses did not refer to the cost of such visualisation approaches as infection control teams did (i.e., they described them as prohibitive in terms of cost) the receptiveness of automated solutions and potential effectiveness towards improvement of HH could be an indicator for further research and investments.

Sub-theme: Ineffectiveness of posters

As in the case of infection control teams, nurses from paediatric services indicated that posters tend to be bypassed by healthcare staff,

> "*Lots of posters and lots of information in departments that folks just … and you just bypass."* (nurse 12, female)

And another added,

> "*Within the hospital we're flooded with posters and visual information you know … and you skim it you don't necessarily read it.*" (nurse 11, female)

6.6.3.2.5 Assimilating HH behaviour for intervention success

Nurses indicated that assimilating HH behaviour and placing it in the centre of patient care is key for intervention success. In order to achieve this success three intervention aspects are important and pertain to the identified sub-themes: 'reminding, repeating, reinforcing', using elements of shocking and understanding the consequences of HH behaviour via the provision of feedback.

Sub-theme: Reminding, repeating, reinforcing

In relation to the first sub-theme, participants said it is important to remind, repeat and reinforce the desired behaviours. For example, a participant noted,

> "*I think it's the repetition and reinforcement. I think education is really important and then if you understand why you're doing something then you're much more likely to do it. I think you just need constant reminders and I think it would be quite useful. It reminds you of what you should be doing*." (nurse 6, female)

Sub-theme: Using elements of shocking

Using elements of shocking in pertinent intervention was, also, suggested to be impactful towards HH. For example, a participant said,

> "*Maybe we need to have quite a brutal poster that shows maybe someone at a queue and the last person actually died because they had to wait in front of the queue and that one stick out on my head because it's like … shocking. So, maybe you need HH posters that are not maybe too brutal but maybe to get to the point of I need to wash my hands*." (nurse 12, female)

Sub-theme: Understanding the consequences of one's own behaviour via providing feedback

Understanding the consequences of one's own behaviour via providing feedback was the third sub-theme. A nurse said,

> *"I think for me personally understanding the consequences of not being good with my HH does improve it. So, when you look at line sepsis and you get line sepsis at the neonatal unit every 5 incidences of line sepsis there's an increase in the number of babies with cerebral palsy. So, there's a positive correlation between line sepsis and incidences of cerebral palsy and that sort of things and you think … that makes you think of what you're doing. I do need to gel me."* (nurse 7, female)

6.6.3.2.6 Need to give voice to staff in the decision and policy process

The sixth and final theme pertained to the importance of giving voice to healthcare staff in the decision and policy process thus highlighting once again that a co-design approach in the development of HH and IPC interventions is key. Within this theme, three sub-themes emerged namely, tension between the ideal and practice, being compliant and lack of autonomy and being intervened on.

Sub-theme: Tension between the ideal and practice

This sub-theme highlighted the value of the Delphi experts' recommendations as well as the challenges in applying them in practice. For example, a nurse described that,

> *"Yeah I do think getting staff involved … I think there will be staff willing to participate and help with that. Cause again you're seeing from a professional point of view you are developing within yourself which is always encouraged and you're also helping the wider world. But we are very limited in the time we have available, it's becoming more and more difficult*

to participate in online training so I think it will need to be funded time, extra time." (nurse 12, female)

And another nurse noted,

> *"Theoretically it's great and we should all be involved in it, and we should try to tailor whatever intervention into what we're doing."* (nurse 6, female)

The above examples reflect the eagerness of healthcare staff to contribute in intervention development as being the professionals who deal directly with HH and IPC practice and comprehend the remits of the job. However, their potential participation in such process needs not to obstruct their clinical duties which appears to be already bound with time-constraints.

Sub-theme: Being compliant

The second sub-theme pertained to healthcare staff being compliant with policies especially when these are developed by people who do not know from the inside the demands and challenges of clinical practice. For example, a nurse said,

> "*I think whatever is put in place it's nurses who go along with it and we have no other option but to do that like. Sometimes the policy makers aren't the persons who actually do the task*." (nurse 13, female).

Sub-theme: lack of autonomy and being intervened on

Lack of autonomy and being intervened on as a third sub-theme added another dimension in staff's participation in the decision and policy process. For example, nurses' scepticism as to the actual exclusion of nurses from the policy process and the various restrictions imposed within their system was expressed,

> "*We know it is us nurses who will be just told this is what you have to do. It's like infection control nurses tell you, you can't have this, you can't have that and it just almost feels*

> *reckoning and unhelpful because there is no explanations and we’re not involved in the policy process and even this which gives us a voice or something that we would normally don’t have voice will make no difference to what happens to us on the floor. Here’s my personal views*.” (nurse 6, female).

The above examples highlight on one hand that taking decisions and developing IPC-related policies is not, nor should be done by people out with clinical practice or without an understanding of the demands of clinical practice. On the other hand, they suggest that the ‘interventionee’ mindset of healthcare staff should be ‘lifted’ into a more active and participatory dimension that empowers and gives more autonomy to staff.

6.7 Discussion

The current focus group study formed the 3rd and final Phase of this research. The aim of the focus group study in Phase 3 was twofold. Firstly, it aimed to gather the opinions, perspectives and recommendations of focus group participants based on their everyday clinical practice regarding IPC and HAIs along with the concepts of theory and visualisation. Secondly, it aimed to present part of the key experts' recommendations (Phase 2) to focus group participants, seek for their opinions and gather further suggestions on how pertinent interventions can be developed and improved. A discussion of the study's key findings in relation to the literature as well as the strengths and weaknesses of the study are included in the following sub-sections.

6.7.1 Discussion of key findings

Participants in both focus group types strongly highlighted various factors that influence their adherence to hygiene policies thus affecting the effectiveness of interventions and pertinent supporting strategies and programmes. The infection control teams underscored factors which are inherent to healthcare staff. They highlighted the role of attitudes and beliefs of healthcare staff in the adherence of hygiene policies suggesting their lack of knowledge and low understanding of the consequences of not adhering as barriers. However, infection control teams highlighted other exogenous factors pertaining to time constraints which restrict staff from adhering to hygiene policies as well as the role of leadership from a managerial point of view in promoting adherence.

Nurses from the paediatric services agreed that education is an important factor and suggested that they need to be kept up to date especially when practices may change over the years. Nurses, however, raised other barriers to adherence related to deficient facilities and resources as well as the negative impact that frequent handwashing can have on them (i.e., skin irritation). What is interesting in this data is that the two focus group types provided different examples of factors influencing IPC practice. Although the factor of education in its wider conceptualisation was suggested by both focus group types yet it was approached differently as infection control teams referred to lack of knowledge and limited awareness of the consequences and nurses from paediatric services referred to the need of training and being kept up to date. The infection control team highlighted a range of exogenous and endogenous factors whereas nurses from the paediatric services concentrated more on exogenous, environmental factors that hinder their practice.

The above distinction demonstrates similarities with previous work which considered attribution theory (Kelley and Michela 1980; Weiner 1982) in IPC practice. With its foundations in social psychology, attribution theory refers to the explanations that people give to specific behaviours through making inferences or ascriptions about these behaviours (e.g. by ascribing blame to someone else) (Malle 2011). A key aspect of this theory is the differentiation of the causal factors of behaviour which can be internal or external to one own's behaviour (Forsterling 1988). Specifically, when internal attribution takes place, individuals regard themselves as being in control of their actions and behaviours and accountable for the outcome. However, when external attribution is applied, individuals attribute their behaviours and thus the related outcomes to situational or environmental factors which are out with their control (Forsterling 1988; Murray and Thomson 2009).

In light of the above distinction, it appeared that in the current study nurses from paediatric service attributed the causal factors for low adherence to hygiene regulations primarily to situational and environmental reasons (i.e., external attribution). However, the infection control teams agreed on the value of one's own accountability for the behaviour and outcomes in IPC practice (i.e., internal attribution). This finding highlights the importance of understanding the nature of the causes of IPC behaviours and suggests that fruitful insights can be offered via the lens of social theory. Lending further support to this finding, is a study by Morrow et al. (2011) about staff perceptions of the sources and control of MRSA. According to the authors, healthcare staff tended to blame everything and everyone but themselves in relation to the causes of MRSA (i.e., external attribution). In addition, motivational and normative biases were detected in that staff attributed their team success on the team members' traits and overall performance (i.e., internal attribution). The authors characterised these conceptions as being biased on a cognitive level and urged for better interorganisational policies and support for healthcare teams when making attributions for the HAIs problem. Towards this end, the contribution of the infection control teams as shown in the current focus group study can have a key role for best IPC practice.

Beyond the insights gained in relation to attribution theory, numerous studies have been published on the reasons influencing hygiene compliance with a considerable amount of them focussing on HH (e.g. Teker et al. 2015; Rynga et al. 2017; Graveto et al. 2018) and only very few investigated factors for low adherence in the wider IPC context (e.g. Valim et al. 2014) or other aspects of hygiene (other than HH) such as use of personal protective equipment (e.g. Hakim, Abouelezz and El Okda 2014). This literature evidence suggests on one hand the importance of HH and determining the factors that affect staff adherence to related policies. However, it also highlights that the wider IPC context and the risk factors influencing related practices needs to be further elucidated. A scoping review by Griffiths et al. (2009) investigated the impact of organisation and management factors on IPC in hospitals. Apart from the identification of the related risk factors, the authors noted that being aware of the risk factors allows for analysing and evaluating the wider healthcare context thus enhancing IPC practice and improving patient care. They noted, however, there may be cases where no direct remedial action can take place (e.g. when there is high staff turnover). This suggests that the healthcare context is a dynamic and ever-changing environment where erratic changes can occur. As such, the necessity to constantly delineate the causal factors of IPC behaviours through multiple dimensions is required.

The above proposition was aptly reflected by a participating nurse in the current study who stated that HH is just one aspect of care provision amongst other aspects of care that have increased over the last several years that have an overall effect in patient care. It is thus the current author’s opinion that more research is required as to investigating factors influencing adherence to hygiene policies among healthcare staff from a wider and more inclusive perspective. The current focus group study has moved towards addressing this issue. The study has additionally explored the opinions and perspectives of two distinct types of healthcare staff whose voice was heard thus having the potential to inform more tailored interventions.

In relation to the policies which underpin IPC practice, participants from both focus group types clearly described that these policies are primarily national which in most of the cases inform the development of local (i.e., across NHS Health Boards) or even ward-based guidelines. This flexibility in the adoption of current policies and consequent development of new ones possibly reflects the wider consideration of the hospital's or ward's needs or even the geography or size of the setting. This may suggest that a one-size fits-all approach in policy development and adoption is not ideal thus supporting the need for well conceptualised interventions adjusted to the institution and the individuals. Although the usefulness and appropriateness of the hygiene related policies currently used were not questioned by participants, it is the current researcher's belief that the aforementioned concept of flexibility in policy development and adoption needs to be a priority. The Department of Health's review on national evidence-based guidelines for preventing healthcare-associated infections (epic3) clearly indicates that the guidelines are subject to timely and frequent review and modification based on practice and local needs (Loveday et al. 2014). Further extending this assertion, it is the current author's perspective that any intervention that aims to support healthcare staff in their IPC practice would benefit from being tailored to healthcare staff and their healthcare institution following implementation, evaluation and frequent review (Kirkpatrick 1976).

Thoughtful considerations as to the concept of intervention in the context of IPC and HH were provided by infection control teams and paediatric nurses respectively. Infection control teams regarded interventions as a holistic approach involving education of staff around IPC during observational audits and implementation of policies as well as the engagement of leadership within this approach. The notion of a holistic approach seems to corroborate findings from Phase 2 of this doctoral research according to which key experts highlighted the high value of multicomponent interventions when compared to single component interventions. Interestingly, the mere presence of the infection control team was suggested as being another powerful way towards positively influencing staff's IPC practice. This suggestion may indicate that the physical presence of people with specific knowledge regarding IPC and authority to examine related procedures and practices can be a simple yet effective interventional approach. This potential effectiveness may lie on the concept of 'visibility' of infection control staff which stems from their physical presence.

On the other hand, nurses from paediatric services did not engage at the same extent as the infection control teams and seemed not to comprehend in depth the nature of the question (i.e., "*What do you think an intervention is in the context of IPC and HH?*"). In essence, paediatric nurses experienced interventions as specific and instrumental in nature. They, also, appeared to regard the use of posters as a ubiquitous intervention within their clinical environment underlying at the same time it is an approach with a limited fit for purpose as people tend to bypass them. The overwhelming use of posters as reported by nurses corroborates the findings of the Delphi study (Phase 2) suggesting this may not be an effective approach towards promoting IPC practice and changing healthcare staff's related behaviours. A poster "overload" has, also, been identified by a recent study (Sendall, McCosker and Halton 2019) which focussed on the concept of HH among hospital cleaning staff. Based on the wider IPC perspective of the current focus group study the use of posters may thus be contested, especially when they are designed with the ambition to positively influence healthcare staff's behaviour change.

With regards to the types of visualisations used in pertinent interventions a wide range of them was reported by participants including paper-based visualisations (i.e., poster, leaflet, care plan document, presswork), TV and radio campaigns as well as interactive visualisation approaches such as the use of germ-simulating gel and UV light to depict the spread of pathogens, and sensor-based flashing lights triggered when healthcare staff have not performed the required IPC practice. The infection control teams reported a wider range of visualisation approaches and this is reflective of the spectrum of visualisation approaches that they utilise thus denoting their perceived and actual significance for IPC. The interactive visualisation approaches were embraced by healthcare staff from both focus group types suggesting that staff's actual engagement with an intervention and use of technology may have the potential to lead to positive outcomes. In addition, such interactive approaches could address the issue of time constraints as was extensively reported by healthcare staff (e.g. by the use of automated flashing lights requiring immediate action) as well as the overwhelming feeling of 'boredom' linked with paper-based approaches (e.g. posters, signs) which staff tend to bypass (e.g. by the use of simulated scenarios using gel and UV light for depicting pathogens spread). Arguably, the issue of time constraints may be an evident problem in large and smaller healthcare institutions while being bound with organisational-, and funding-related barriers (e.g. owing to understaffing). Acknowledging that the solution to this problem may extend beyond the scope of the current thesis, more research is required as to how to bridge the gap between the issue of time constraints and the effective implementation of IPC practices as dictated by the relevant policies.

In relation to how interventions can be effective leading to sustained outcomes, the infection control teams put forward that effective leadership and taking personal responsibility and accountability regarding IPC practices are key contributors. The latter point was in concordance with the nurses from paediatric services who highlighted the importance of 'being conscious' of one's own actions. These findings are in line with Hei et al. (2018) who developed a prevention bundle for paediatric healthcare-associated viral infections. In that bundle, the active engagement of healthcare staff was required, and they were committed to driving change and improvement. Also, team leaders were responsible for driving change passionately and with commitment as well as acting proactively towards prevention of infections. The current findings are also in agreement with other studies which highlighted the vital role of the concept of leadership in IPC (e.g. Gould, Gallagher and Allen 2016; Knobloch et al. 2018). Overall, there seems to be strong evidence to indicate that effective leadership and training of leadership skills should be a priority particularly for nursing academic curricula as well as for the continuing personal development of healthcare staff.

Patient safety cannot be characterised as a 'individual versus system' responsibility. This means that healthcare staff are expected to be accountable for their practices, decisions and actions. Equally, the healthcare system must be supportive and provide the necessary tools and resources in order for healthcare staff to do their job (Beet, Benoit and Bion 2018). Taking the above into consideration, in the current study the identified concepts of leadership as well as responsibility and accountability underscores their key role in successful interventions irrespective of the intervention development approach they may adopt (i.e., systems-wide or focal).

Healthcare staff from infection control teams and paediatric services in this focus group study considered the Delphi key experts' recommendations presented to them as useful with special reference to the concept of co-design. However, the feasibility of these recommendations was questioned due to practical difficulties. This notion was more persistent by nurses from paediatric services who explained that the work remits and demands, institutional constraints and staff exclusion from the policy process are the main reasons for participants' scepticism (i.e., tension between the ideal and practice). The latter point regarding healthcare staff 'having a voice' in decision making was also supported by the infection control teams. Healthcare staff and especially nursing staff as direct caregivers are the individuals who know at first-hand how their system works, what difficulties they face, and which interventional strategies are more effective than others. As such if those individuals have no substantial contribution in policy-making there is a 'danger' that other parties with potential competing interests to be involved in the process and whose only voice is heard (Oestberg 2013).

As in the case of shared decision-making model (Elwyn et al. 2010) where clinicians and patients come to mutually agreed decisions following sharing the best available evidence, a similar 'shared policy-making' approach could be considered and adopted by healthcare organisations on a national and international level. Support to such an approach may be given by a type of co-design called Experience-based Co-design (EBCD). This is an approach that explicitly aims to draw together staff and patients for improving the quality of care (Bate and Robert 2007; Donetto et al. 2015). Specifically, EBCD is underpinned by a range of methodologies including participatory action research, narrative and learning theories and design thinking. Based on them, the rationale of EBCD is to coalesce staff and service users in order to actively collaborate and being accountable for all decisions throughout the quality improvement process (Dimopoulos-Bick et al. 2018). Taking this into consideration and looking at IR2 findings (Chapter 5), video-reflexive ethnography (Wyer et al. 2017) may be a promising interventionist research approach that clearly combines theoretical and visualisation approaches involving both healthcare staff and patients within a participatory overarching methodology.

The current study, also, indicates that the establishment of a participatory approach could lead to strengthening healthcare staff's feeling of responsibility and accountability in relation to performing IPC practice. Considering that a participatory approach and leadership were found to be key in intervention development in IPC, further research could focus on identifying what types of leadership (Sfantou et al. 2017) would be most beneficial.

6.7.2 Strengths and weaknesses

To the author's best knowledge this is the first focus group study to investigate healthcare staff's opinions, perspectives and recommendations around the IPC and HAIs along with the concept of theory and visualisation. Despite there is a large volume of published studies exploring aspects of healthcare staff's IPC practice (e.g. factors for low HH adherence), the current study has looked at specific types of healthcare staff and in relation to the use of theory and visualisation not previously explored. Therefore, the empirical findings in this study provide a new understanding of these groups' perspectives and improve the evidence base. Another strength of the study from a methodological point of view was the sequential link with Phase 2 of this doctoral research. The current study was partly informed by the findings of the Delphi study and focus group participants were presented with a summary of the Delphi key experts' recommendations. This approach enhanced the rigour of the study and the doctoral research overall. Another strength of the study pertains to the decisions taken in relation to sampling and recruitment processes. These were based on justified decisions retaining a systematic audit trail throughout the research. In addition, the focus group discussions were homogenous in terms of participants being of similar or identical professional role, thus allowing group dynamics to unfold and avoiding dominant personalities to prevail.

The current study, however, is not without limitations. Despite attempts to recruit a minimum of eight participants in each focus group this was not achieved. The researcher established frequent communication with the gatekeepers well in advance to allow for the recruitment plan to come to fruition. However, the fact that the recruitment process commenced in July when potential participants were already or were about to be on annual leave may explain the presence of recruitment challenges. In practice, even if groups where smaller than planned, participants engaged satisfactorily with the discussion. Smithson (2008) suggests that smaller groups provide a fostering environment where all participants can actively engage thus allowing interesting and relevant data to emerge. In the case of one of the conducted discussions with three participants, Ritchie and Lewis (2003) regarded triads and dyads as an effective hybrid form of in-depth interviews.

6.8 Conclusion

This focus group study set out to explore healthcare staff's opinions in a range of issues related to IPC and HAIs along with the concepts of theory and visualisation. In addition, two types of healthcare staff participated coming from infection control teams and paediatric hospitals. This allowed to directly consider findings from the previously conducted Delphi study targeted to each of the two focus group types thus enabling to identify convergent and divergent responses between the IPC and paediatric groups. Despite the presence of endogenous and exogenous factors hindering staff's adherence to hygiene policies the findings of this research support the idea of developing behaviour change interventions considering the combination of theory and visualisation. An implication of the study is the benefit of healthcare staff's substantial participation in decision and policy-making which has the potential for effective and sustainable interventions. However, answering how staff's participation in decision-, and policy-making can be enhanced was not the focus of the study, further research is required to clearly understand it. In addition, the low acceptability of the use of paper-based visualisation approaches, primarily posters, and their low self-reported effectiveness renders such approaches unsuccessful in the wider context of behaviour change in IPC. On the other hand, dynamic visualisation approaches making use of new technologies have the potential to foster IPC interventions. As healthcare staff are in the centre of patient care, their role in the success of behaviour change interventions is of paramount importance.

Chapter 7

Discussion

Chapter 7

DISCUSSION

7.1 Introduction to the Chapter

The final chapter aims to synthesise and discuss the study in light of pertinent research evidence and to present recommendations for progressing applications of theory and visualisation in the field of HAIs and IPC. The overall aims of this research will be restated with reference to the key findings of each of the three conducted Phases. The recommendations will be presented and expanded following a summary of what has been learned about the concepts of theory and visualisation in the context of IPC and HAIs for the development of behavioural interventions. This will then allow the recommendations to be outlined diagrammatically and further discussed. A presentation of the strengths and weaknesses of the study will follow and the original contribution to knowledge of this research will be discussed. This contribution will be further mapped on the implications of the research for practice and policy. Finally, the author's personal reflections on the process of the study will be highlighted.

7.2 Review of the thesis

7.2.1 Overall aims of the research

The research aimed to explore the field of IPC and HAIs in depth with a view to developing evidence-based recommendations for designing behaviour change interventions that combine theory and visualisation. To achieve this aim the overarching research question that guided this research was:

> *"How can theory and visualisation best inform behaviour change interventions designed to help healthcare staff prevent and control HAI?"*

The research comprised three distinct Phases, each informing the next but also making a standalone contribution thus enhancing the knowledge base on the concepts of IPC, theory and visualisation. Research evidence on these concepts as presented in the introductory Chapter highlighted the importance of combining theory and visualisation in the development of behaviour change interventions in the wider healthcare context. However, this also revealed that little was known on how can theory and visualisation best be combined for developing IPC-related interventions. The study thus aimed to move beyond existing research evidence and contribute to the limited evidence base in the field of IPC and HAIs. This need formed the basis for exploring these concepts through two integrative literature reviews (Phase 1) and underscored the importance of conducting additional empirical research (Phases 2 and 3) using a sequential multi-methods pragmatic inquiry approach. The aforementioned recommendations are presented later in this Chapter (section 7.4) considering the Phase findings for both concepts of theory and visualisation.

7.2.2 Key findings

The following sub-sections (7.2.2.1-7.2.2.3) summarise the key findings in relation to the research questions asked in each of the three phases of this research.

7.2.2.1 Phase 1 findings

The findings from IR1 and IR2 furthered understanding on aspects related to HAIs along with the range of theories (IR1) and visualisations (IR2) reported in the identified studies, the structure and application of the related interventions and their effectiveness.

In IR1 a wide range of theories were detected which were clustered in three categories: traditional and psychology-based theories looking at the integral aspects of human behaviour (e.g. attitudes, social norms), theories stemming from less behavioural-based sciences (e.g. engineering, marketing) targeted at positively influencing the system and the wider context within which teams perform hygiene-related practices and theories with a policy-, and guideline-orientation underpinned by a nursing evidence-based perspective (e.g. 'My 5 moments of HH' by WHO). The above categorisation is a key finding of IR1 as it goes beyond identifying behavioural theories only. This differentiates it from previous research in this area (e.g. Huis et al. 2012) thus highlighting the distinct value of the review. This point is further discussed in light of pertinent research in section 7.3.1 below.

The findings, also, demonstrated that multi-component interventions outweighed single component interventions with the former targeted primarily on improving HH and leading to improved and sustained outcomes. This finding suggested that interventions targeted at improving HH were not only more likely to lead to statistically significant results (8 out of 9 interventions across a total of 16) but were importantly more likely to lead to sustained effects that ranged from 6 to 20 months post-intervention (5 out of 9 studies targeted at HH). This suggested that improving HH can be a simple and effective approach towards tackling HAIs (see Chapter 3, table 3.4).

It is important to highlight that multicomponent interventions and interventions that applied a combination of theories are two distinct concepts. In the case of multicomponent interventions, multiple intervention components were utilised to achieve the desired outcomes. For example, the intervention by Pulcini et al. (2007) employed various components including educational meetings, audit with feedback provision and use of reminders. However, their intervention was guided by a single theoretical approach (i.e., PDSA cycle). Thus, it cannot be necessarily implied that multicomponent interventions have applied multiple theories. These two concepts for all included studies are presented in table 3.3 (Chapter 3) along with other study characteristics.

Although the identification and/or comparison of what specific types of theory are more suitable or effective than others was not a primary consideration in IR1 (as it was explored in conjunction with other aspects of the identified interventions), important observations were drawn. Specifically, a key finding was that the majority of the included studies did not justify the selection of the specific theory or theories that informed the reported intervention. Nor was the success or failure of the interventions attributed to the selected theory. Such an attribution was particularly challenging in the case of multicomponent interventions, where it was not clear if the degree of effectiveness was linked to either particular components and content or the theoretical basis of the intervention. This was a key finding but also a limitation of the reported interventions as acknowledged by some of the authors. Nonetheless, it appeared that interventions which were based on a combination of theories might not be an optimal decision when developing IPC-related interventions. As shown in table 3.4 (Chapter 3), 2 of the 5 interventions which used a combination of theories resulted in positive outcomes (Sharma et al. 2015; Huis et al. 2013) whereas only 1 intervention (Huis et al. 2013) led to a sustained effect.

In IR2 a wide range of visualisation-centred interventions were identified and categorised using a quadrant map as: context/team oriented interventions involving the conscious engagement of participants, individual/person oriented interventions involving the conscious engagement of participants, individual/person oriented interventions involving the subconscious/subliminal engagement of participants and context/team oriented interventions involving the subconscious/subliminal engagement of participants (see Chapter 4, figure 4.3). Another key finding of IR2 was that the majority of the included studies (18 out of 23) were regarded as single component in that they employed a single visualisation component or more than one component of the same visualisation approach (e.g. use of different visual posters or use of posters and flipcharts).

A key characteristic pertaining to the structure and application of the identified interventions was the provision of feedback to participants which was the central and explicit focus on 8 of the included studies. With regards to the effectiveness of visualisation-centred interventions, although 14 of the studies were found to be successful there was no particular pattern nor indication that single-component interventions were more effective than multi-component. That said, all 5 multi-component interventions were found to be effective with 2 of them (out of 4 studies overall) having explored and achieved intervention sustainability. With reference to the quadrant map (see Chapter 4, figure 4.3), it was found that visualisation-centred interventions that were targeted at the person/individual level and involved the participants' conscious engagement (i.e., top-left quadrant) were more effective followed by visualisation-centred interventions that engaged wider teams at a conscious level (i.e., top-right quadrant). A key finding was that all four studies found to be unsuccessful employed posters as the interventional approach a finding that raises questioning about the effectiveness of poster-based interventions. Finally, as in the case of IR1, HH was the central focus of the majority of the included studies (i.e., in 15 studies) highlighting again the key role of this behaviour in IPC.

The two IRs answered specific research questions and contributed towards enhancing the knowledge base. They raised however further questions which are generally not found in published research papers. Such questions were, for example,

- "*Why were the chosen theories and visualisations favoured compared to others?*",
- "*Why were the particular intervention structure and content selected?*",
- "*How can interventions be improved in terms of effectiveness leading to sustainable effects?*"

The identification of these questions was key not only because they highlighted specific areas in the process of intervention development that require scrutiny and elucidation but also because they offered a new perspective upon which the research further evolved.

7.2.2.1.1 Recent literature

Due to the necessary scrutiny, consequent time constraints and the requirement to re-involve the review team, it was not feasible to formally update the two IRs that were originally conducted at the commencement of the doctoral study. However, application of the related search terms and an informal evaluation by the current author suggests that four additional very recent studies seem to potentially meet the inclusion criteria for IR1 (Aziz et al. 2017; Erichsen Andersson et al. 2018; Jeihooni et al. 2018; Padoveze et al. 2019) and seven studies for IR2 (Park and Seale 2017; Kane, Finley and Brown 2018; Jacob, Herwaldt and Durso 2018; Caris et al. 2018; Dippenaar and Smith 2018; Crofton and Foley 2018; Harisson et al. 2019). These studies, and other recent pertinent literature have informed subsequent discussion of the study findings where relevant.

7.2.2.2 Phase 2 findings

Following on from Phase 1, the 3-round Delphi study in Phase 2 aimed to explore the questions previously raised and address the related gaps. A heterogeneous and multidisciplinary panel of 18 international key experts took part in the study. With response rates exceeding the minimum 75% threshold between rounds, key experts' responses in round 1 resulted in the development of two intervention scenarios. In scenario 1 intervention development considered a systems-wide approach involving the whole healthcare organisation aiming to reduce infection rates. On the other hand, scenario 2 focused on developing focal interventions within small healthcare teams aiming to increase HH compliance. In the subsequent rounds 2 and 3 statements were devised pertaining to the concepts of theory, visualisation, the development of interventions and the long-term effectiveness and sustainability of interventions. By anchoring their responses either on scenario 1 or 2, key experts were asked to rate these statements or indicate a rank order when necessary.

By the end of the study a menu of intervention options which received high consensus (i.e., more than 70%) regarding the development, theory, visualisation and effectiveness of pertinent interventions was developed in light of the two intervention scenarios (see Chapter 5, figure 5.2). Apart from the usefulness of the experts' collective agreement, a key characteristic of this menu is that it does not exist in a vacuum. In other words, experts' collective agreement and thus pertinent recommendations are anchored in related scenarios. The generation of the two scenarios suggested that a decision needs to be taken early in the process of intervention development as to the nature of the intervention. This may include a consideration of where the intervention may take place (i.e., context), what the intervention is aiming to achieve (i.e., intervention outcome) and who is going to receive or engage with the intervention (i.e., population). Moreover, the developed menu of options provided an indicative set of highly and collectively agreed statements. As such the content of the menu may not be exhaustive but it provided useful insights stemming from multidisciplinary, and highly knowledgeable experts who were interested in making a contribution in the field. Taking the above into consideration the Delphi study provided an important opportunity to advance the understanding of the concepts of theory, visualisation and their optimal combination in the fields IPC and HAIs.

7.2.2.3 Phase 3 findings

Findings from Phase 2 led to Phase 3 of the research. Specifically, the focus group discussions with healthcare staff in Phase 3 were tightly linked to phase 2 as they mirrored the Delphi key experts' suggestion that healthcare staff should have an active engagement in intervention development and their voice needs to be heard. Importantly, the distinction of the two focus group types, one with infection control teams and one with nurses from paediatric services, reflected the two intervention scenarios that emerged from the Delphi study in Phase 2. The infection control teams reflected scenario 1 of the Delphi study with a focus on improving IPC practice and reducing infections. The focus group with nurses from paediatric services reflected scenario 2 with a focus on improving HH practice and adherence to related policies. This distinction was particularly insightful both in terms of drawing comparisons between the participants of the Delphi and focus group study, but also within the focus groups to identify any similarities or differences between the two different participating teams of healthcare staff.

A wide range of factors influencing IPC and HH practice were referred to by the participants. A notable distinction was that infection control teams identified a mixture of factors influencing IPC practice which were both endogenous to healthcare staff (e.g. attitudes, beliefs and lack of knowledge) as well as exogenous (e.g. busyness of the wards and time constraints). On the other hand, nurses from paediatric services described primarily exogenous factors that influence their HH practice as for example resource-related, and the need for training and education. Conversely, the infection control teams appeared to display a more 'interventionist' mindset. Also, nurses from paediatric services seemed to have an 'interventionee' mindset in that they had a more passive and recipient perspective regarding any support provided in improving their HH practices. Healthcare staff from the infection control teams saw themselves as individuals who empower healthcare staff towards IPC practice without imposing changes via an authoritative and obstructive manner. This was reflected by paediatric nurses who acknowledged that even the mere presence of the infection control teams in the wards has a positive impact on staff's HH performance.

With regards to the concept of visualisation both focus group types agreed on its importance in IPC and HH practice across the board and recognised that some forms of visualisations are more successful than others. For example, as identified in the previous study phases of this research, the use of paper-based visualisations and particularly posters were not favoured by the focus groups participants who seemed to bypass them thus ignoring their content. The multi-stage adoption of visualisation approaches in IPC was highlighted by the infection control teams in terms of the range and stages involved thus denoting the importance of visual approaches in IPC practice. Paediatric nurses regarded visualisation as a means to addressing challenges in clinical practice in relation to improving HH and clinical practice.

In terms of the success of interventions, infection control teams mentioned that this is a multi-faceted issue and comes through the healthcare staff, management and nature of the implemented intervention. Paediatric nurses focussed on the necessity to understand HH and provided specific suggestions as to how interventions can be facilitated. Finally, the Delphi experts' recommendations received some scepticism by both focus group types regarding the practical challenges in applying them. However, there was a strong agreement that a participatory approach in intervention development involving healthcare staff in decision and policy process are key towards strengthening staff's feeling of responsibility and accountability in relation to performing IPC practice.

7.3 Triangulation and discussion of the research findings

The three Phases of this study utilised two methods of triangulation i.e., methodological and data triangulation (see Chapter 2, section 2.4.3). Phase 1 included two IRs with both qualitative and quantitative elements in their design. Similarly, the Delphi study in Phase 2 included both qualitative and quantitative aspects, whereas the focus group study in Phase 3 was purely qualitative.

The most important findings and key points from all three Phases are discussed in this section in order to analyse where findings converge and diverge, and to understand this in relation to relevant contemporary research. Figure 7.1 summarises these findings and key points and offers the basis for a discussion in a triangulated manner.

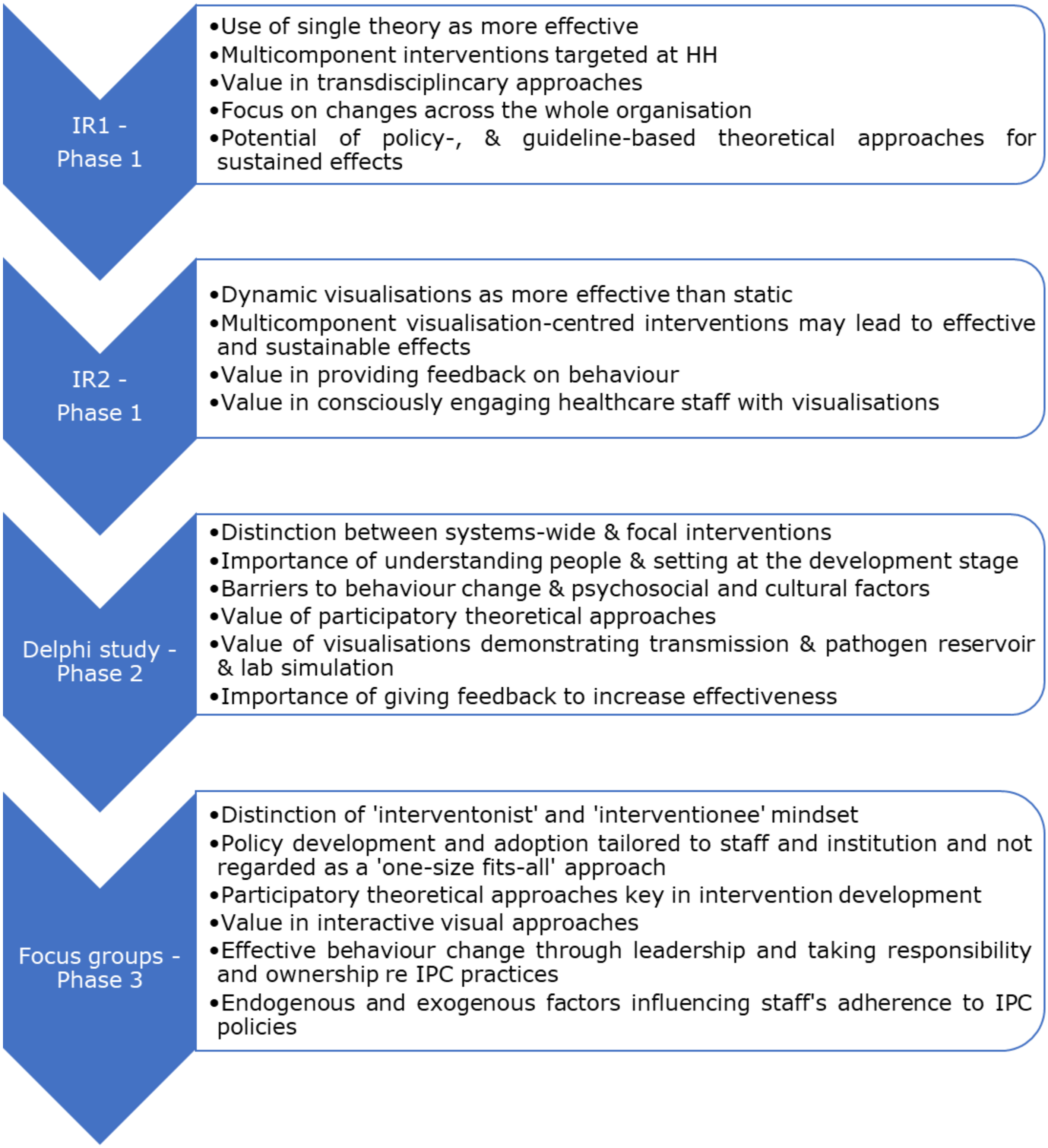

Figure 7.1 Summary of key findings and points from the 3 phases of the doctoral research

7.3.1 Consideration of theory in interventions

This study provided an important opportunity to advance understanding of the concept of theory in interventions in the specific context of HAIs and IPC. Specifically, insights were gained as to the necessity of not seeing the use of theory as a one-size fits-all approach. This was evident across all three Phases of the study and particularly in the Delphi study with the distinction between systems-wide and focal interventions. This was a crucial establishment as it underscored that changing behaviour in the IPC context ranges across a continuum of concepts (e.g. improving HH, decreasing infection rates, adherence to hygiene policies) and is not just a matter of addressing individual behaviour. Within this ambit, both key experts and focus groups participants were directly asked to determine related behavioural determinants through reflecting on the BCT taxonomy (Michie et al. 2013) and self-reported barriers and enablers of behaviour, respectively.

In relation to the above aspect, the systematic review by Huis et al. (2012) aimed to identify behavioural determinants of HH using an inferred retrospective taxonomy of BCTs (de Bruin et al. 2009). Although, adopting their approach would have been potentially useful for the development, for example, of a HH intervention scenario (e.g. to be presented to the Delphi key experts) using the proposed behavioural determinants (i.e., social influence, attitude, self-efficacy, and intention) this approach was not deemed as appropriate for the current study for three reasons. Firstly, as the authors of the taxonomy highlighted (de Bruin et al. 2009) the behavioural determinants proposed emerged from a sample of interventions targeted at improving adherence to highly active antiretroviral therapy. Therefore, this limits the generalisability of the taxonomy to other fields (de Bruin et al. 2009) thus rendering its application to the context of IPC potentially problematic. Secondly, the proposed behavioural determinants by Huis et al. (2012) reflect a more general perspective of the implementation of the identified interventions and could not have mirrored the two specific intervention scenarios presented in the Delphi study and focus group discussions. Thirdly, the scope of IR1 and the study overall was much wider but was tightly linked to specific theory categories presented to Delphi key experts who were asked to consider along with one intervention scenario. As such the comprehensive IR1 mapping approach, allied to the subsequent challenge of specific clinical scenarios, was judged more fruitful for this exploratory study rather than adopting the more limiting Huis et al. (2012) taxonomy.

With regards to the effectiveness of theory-based interventions, findings from IR1 (Phase 1) showed that effective interventions were those that used a single theory to guide intervention development such as Roger's Diffusion of Innovation theory (Basinger 2014) suggesting this may be more appropriate than combining different theoretical approaches. In addition, interventions that were guided by a single theory tended to be multicomponent and targeted at HH (e.g. Creedon (2005) used the PRECEDE model and utilised multiple intervention components including educational handout, poster campaign, use of ABHR, and pre-test observation feedback by poster) (see table 3.3 in Chapter 3 for studies description).

The fact that among the five interventions (out of total 16) which reported a sustained effect, four of them were guided by a single theory may be another indicator of their appropriateness (i.e., use of a single theory) (see Chapter 3, table 3.4). However, the potential benefit of using a single theory was neither supported nor contested in the next Phases of the study. Rather, Delphi key experts appeared to be sceptical as to what type of theory to choose suggesting that much scrutiny of the causes of the investigated behaviour is needed as well as understanding the clinical context and identifying environmental barriers at the intervention development stage.

A potential lack of elucidation of the clinical context and environmental barriers at the outset of the study development may thus explain why the identified theory-based interventions in IR1 targeted at decreasing infections rates did not definitively result in a positive effect. In fact, the need to understand the clinical context as well as factors out with the individual (i.e., exogenous) that influence IPC practice was underscored in Phases 2 and 3 by the Delphi key experts and focus group participants, respectively. In other words, the goal to decrease infection rates in a healthcare setting is affected by factors beyond the individual's control (e.g. virus outbreak, non-compliance to hygiene regulations by visitors) thus rendering the success of a theory-based intervention challenging.

7.3.1.1 Moving beyond traditional behavioural theories

Overall, these findings indicate that interventions aiming to decrease infection rates within a healthcare setting, should also consider use of single theories stemming from less behavioural-based sciences (e.g. engineering, marketing) targeted at positively influencing the system and the wider clinical context. Examples of such theories, as found in IR1, are the STS framework (Lewis et al. 2014) and social marketing (Sharma et al. 2015). The identification of these theories and their value in addressing the IPC challenge, provide strong support to the inclusive nature of IR1 as it is open to any theory and not just behavioural determinants. Thus, moving beyond purely behavioural approaches is an avenue that the study has put forward.

Storr et al. (2013) further corroborated the aforementioned assertion suggesting that embedding human factors principles in IPC-related interventions can strengthen their capacity and capability. The authors explained that a human factors approach, as synonym to ergonomics, allows for better understanding the wider healthcare system where staff interact with each other as well as with patients and the environment thus supporting the optimisation of human well-being and the overall performance of the system (Storr et al. 2013). As yet, it seems that Storr et al.'s (2013) proposition has not been enacted. Specifically, Jacob et al. (2018) highlighted the limited application of human factors approaches in addressing challenges in the spread of infections. Examples of how human factors interventions can make a contribution, according to Drews, Visnovsky and Mayer (2019), include simplifying or redesigning the workflows, improving the equipment design, and clarifying potential ambiguities regarding communication or IPC guidelines. Providing further support to the above human factors examples, Delphi key experts (Phase 2) who chose the systems-wide intervention scenario corroborated the importance of making structural changes in the healthcare environment for intervention success. Despite not providing specific examples as to what these changes may entail, it is assumed that such environmental changes aim to support rather than inhibit healthcare staff's IPC practices.

The above assertions reflect what Kelly and Barker (2016) suggest makes changing health-related behaviour so difficult. According to the authors consideration of the complexity of behaviour itself should be accompanied by a policy-making perspective. Kelly and Barker's criticism was based on the fact that the important role of dimensions which are key in behaviour change other than the individual one such as social, political and economic, have been abstracted from the related contexts. Another recent study by Padoveze et al. (2019) moved beyond the use of traditional behavioural theory, proposing a theoretical framework targeted at HAIs from a vulnerability perspective focussing at individual and collective dimensions.

The identification of theoretical approaches in the current study and especially those that move beyond the traditional psychological theories underscore the need to adopt an ecological approach to behaviour change considering the personal or individual, social and environmental levels that underpin human behaviour (Central Office of Information 2009).

7.3.2 Consideration of behavioural outcomes

Apart from aiming to address challenges related to the spread of infection, the concept of improving HH strongly emerged from all three Phases of this research. In Phase 1, the vast majority of theory-based interventions targeted at improving HH were found to be effective and provided evidence for a sustained effect. This appears to be convergent with the findings of a recent systematic review of systematic reviews (Price et al. 2018) exploring interventions to improve HH among healthcare staff. Despite only one systematic review was of low risk of bias, the authors found that the vast majority of the included reviews reported positive effects of the included interventions across a range of participating healthcare staff and settings. Interestingly, only three of the eleven included reviews explicitly reported the presence or absence of an underpinning theoretical framework. Of them, only one found a statistically significant positive correlation between the intervention effectiveness and the number of theoretical determinants of behaviours used. Also, six of eleven included reviews that extracted HAIs data offered mixed or nonsignificant results. Overall, this corroborates the findings of IR1 according to which the vast majority of theory-based interventions had no or unclear effect on decreasing HAIs (see table 3.4 Chapter 3). Although it may be premature to argue that the selected theoretical approaches in these six studies are not appropriate, it may safely be said that aiming to decrease infection rates is by definition a challenging endeavour irrespective of the selected theory. Thus, the selection of the theoretical underpinning of the intervention as well as the content and delivery of interventions need to be considered in depth. This assertion ties in with the systems-wide intervention development scenario in Delphi study (Phase 2) where positively addressing the HAIs challenge heavily depends on understanding factors related to the individual, team/group and the healthcare institution. This was further supported by the identification of endogenous and exogenous factors in the focus group study (Phase 3).

What is interesting in the data of IR1 is that although there was no dominant pattern of theoretical approaches in terms of their frequency of use, it was indicated that HH needs to be seen as a process of key steps involving primarily the targeted healthcare staff. Such theoretical approaches as found in IR1 are the PRECEDE model (Aboumatar et al. 2012; Creedon 2005), the 'My 5 Moments of HH' (Martin-Madraazo et al. 2012) and the PDSA cycles (Linam et al. 2011). In fact, the value of such a process of iterative key steps is reflected on the use of participatory approaches in intervention development and implementation such as co-design which is not a purely theoretical approach targeted at behavioural factors.

The challenging nature of positively influencing both HH and infection rates is reflected on the 'outcomes staircase' figure which mirrors the author's understanding of how challenging these outcomes are to be achieved (see Chapter 3, figure 3.3). As can be seen in the figure the concepts of HH and infection rates along with surface contamination are situated at the upper part of the staircase. Overall these findings suggest that the primary outcomes which are particularly challenging to be positively altered and sustained (as in the case of HH and infection rates) need to be seen as a change process involving the understanding of the targeted behaviour, understanding the population as well as the clinical context under investigation. This indication resonates with the ideas of Macduff et al. (2017) and Macdonald and Macduff (2018) who highlight the conjunction of pathogens, places and people. Within this ambit, the current study has strongly supported the notion which embraces the value of addressing the HAIs and IPC challenge through a change process. For example, as part of this change process the role of the general public including patient line was highlighted as being important in intervention effectiveness both by Delphi key experts (emerged as a sub-theme; see Chapter 5) and focus group participants (see Chapter 6, sections 6.5.3.2.3 and 6.5.3.2.4). Specifically, nurses from paediatric services explained that patients' parents facilitate IPC practices by constantly putting pressure on healthcare staff to perform HH practice. The facilitatory role of the public -even if unintended- as perceived by nurses may be an indicator that individuals who are not healthcare professionals should be involved in IPC-related interventions.

7.3.2.1 The potential role of the public

Further support to the indication that the public can have a facilitatory role in IPC is provided by a recent scoping review by Fernandes Agreli et al. (2019) looking at the role of patient involvement in IPC interventions and guidelines. According to the authors enhancing patient involvement in IPC practice can establish a more rigorous patient-centred service by actively including them in their own IPC thus leading to increased adherence by healthcare staff. Importantly, the authors highlighted that the best strategies to promote patient involvement in IPC are yet not clear owing to limited research evidence underscoring the necessity for creating an accepting culture that can foster patient involvement in IPC. The authors noted that additional research is required to comprehend how to establish an 'accepting culture' and, explained that factors that hinder this establishment are the lack of role clarity, power imbalances and clinical dominance.

The current research not only highlighted the important role of patient involvement in IPC but additionally underscored the importance of involving other members of the general public such as patients' parents and other relatives. By doing so the burden of IPC practices which appears to be shouldered primarily by nursing staff (as expressed as such by focus group participants in Phase 3) can be dispersed thus plausibly resulting in more effective IPC and enhanced quality of care.

7.3.2.2 Effective IPC practice through effective leadership

Specifically addressing 'how' the involvement of members of the general public can be achieved was not the focus of this research, however the concept of leadership that arose across the three research Phases can provide helpful insights. Specifically, in IR1 the concept of leadership appeared either as the underpinning theoretical approach of the reported interventions (e.g., Huis et al. 2013) or as an interventional element (e.g. Linam et al. 2011). In the Delphi study, the idea that leadership should be a key aspect of multimodal interventions specifically targeted at improving HH compliance was expressed. In Phase 3, the infection control teams clearly suggested that effective leadership is a core component of IPC that has the potential to lead to effective interventions.

The 'prevention and control of HAIs overview' commissioned by NICE (2019) has clearly articulated that leadership should be demonstrated by Trust boards in IPC in order to ensure a culture of continuous quality improvement thus minimising patient risk. Lending further support to the role of leadership in IPC was a recent paper by Hegarty et al. (2019) who sought to understand healthcare leaders' perspectives regarding HAIs guidelines implementation. The authors suggested that leadership is key for supporting the implementation of IPC-related guidelines by providing regular and targeted updates as well as establishing multidimensional educational activities for frontline healthcare staff. It was, also, recognised that such initiatives can be hampered by limited resources and alternative approaches should thus be considered including the use of electronic-based strategies (e.g. reminders).

Hegarty et al.'s (2019) conclusions on leadership and IPC accord with part of the findings of the current research. Specifically, the current research demonstrated that leadership as well as management are integral aspects of an intervention that is aimed to lead to effective and sustainable outcomes in the IPC context. It was, also, suggested that members of staff from infection control teams can be influential leader figures by acting as role models for healthcare staff as well as educating and reminding them about IPC practices. This notion was highlighted by Delphi key experts as well as the infection control teams and importantly the paediatric nurses. The fact that the need for leadership to help address the IPC challenge has been widely embraced, denotes that being open and receptive to guidance and mentoring should underpin healthcare staff practices in IPC. The suboptimal adherence to hygiene practices by doctors noted by focus group participants may be an area of exploration by future research. This could be addressed, for example, by scrutinising what leadership style (Chapman et al. 2014) is more effective across all healthcare staff. Gould et al. (2016) perceived leadership as different forms of directing a group or team and categorised it as managerial leadership, middle management and frontline leadership. Physicians appear to have a moderate to minimal role in these leadership roles, whereas nurses seem to take on leadership roles especially in the frontline leadership category (Gould et al. 2016). Therefore, based on the findings of the current research and in light of the above-mentioned evidence, the inclusion of physicians in IPC-related leadership as well as their active engagement in IPC teams would potentially increase their participation in IPC practices thus weakening their resistance in adhering to related policies.

The need to adopt an inclusive direction towards IPC practices in terms of leadership underscores the key role that a participatory research approach has in addressing the IPC and HAIs challenge. This was a notable finding of the current research not only in terms of the theoretical underpinnings of interventions (see IR1, Chapter 3) but also in relation to the conscious use of, and engagement with visualisations in pertinent interventions (see IR2, Chapter 4). The nature of participatory research approaches were highlighted in all three Phases and expressed primarily by the use of co-design and co-development as the underpinning theoretical approach of interventions as shown in IR1, and further corroborated in the Delphi study and focus group discussions. However, participatory research approaches require the involved individuals to consciously and actively engage with all stages of the design process, including the co-development and co-implementation of interventional solutions (Robertson and Simonsen 2013). Although the necessity for such an in-depth engagement of stakeholders was not entirely clear at the end of Phase 1, it was beyond doubt by the end of Phase 3 that the role and voice of healthcare staff as direct performers of IPC-related practices needed to be enhanced. However, addressing practical challenges tightly linked to staff’s engagement require further elucidation as some scepticism about the time requirements were noted by participants.

The above suggestion resonates with other propositions that participatory research approaches remain unexplored across behaviour change projects (Carvalho et al. 2017). Importantly, a recent systematic review by Peter et al. (2018) that aimed to identify strategies promoting IPC in acute care hospitals further corroborates the absence of participatory approaches in the field. Among the 10 included studies, only 2 utilised a participatory training approach and 1 a partly participatory educational approach. Interestingly, healthcare staff's (i.e., infection control link nurses) involvement in the process was limited to discussions with other key stakeholders over problems and controversial points raised regarding HAIs-specific guidelines. The limited utilisation of participatory approaches in terms of their depth and involved stakeholders as shown above attributes more value to the suggestion of the current research in engaging all healthcare staff involved in IPC (and not only infection control teams) across a range of tasks ranging from decision-making, and development of policies to the design and implementation of interventional strategies.

7.3.3 Consideration of visualisation in interventions

The above suggestions on the importance of participatory research approaches in IPC illuminates a key consideration that allows a direct link to be made with the concept of visualisation, and how this could optimally be combined with theory in pertinent behaviour change interventions. This consideration relates to the conscious engagement of stakeholders within participatory approaches. Looking back at the findings of IR2 (Chapter 4) and especially at the mapping modes of orientation and engagement figure (see figure 4.3), the majority of the included visualisation-centred interventions required the participants' conscious engagement with the interventions (i.e., top quadrants) with a particular focus on the context and team level (i.e., top-right quadrant).

In terms of their effectiveness, it appeared that visualisation-centred interventions that were targeted at the person/individual level and involved the participants' conscious engagement (i.e., top-left quadrant) may be more effective followed by visualisation-centred interventions that engage wider teams at a conscious level. However, owing to the range of outcomes across the two top quadrants and the absence of any indicative pattern no firm conclusion can be drawn as to what approach is more suitable for example towards improving HH or decreasing infections rates.

Despite that, the two intervention scenarios (‘focal’ and ‘systems-wide’ approach to intervention development) as emerged in the Delphi study may provide a basis to assume that interventions targeted at the person/individual level requiring their conscious engagement (i.e., top-left quadrant) may more effectively address positive HH outcomes. Similarly, the top-right quadrant of IR2 may better reflect interventions intending to bring about changes across the whole organisation as for example decreasing the spread of infections. The aspect of conscious engagement was also supported by focus group participants. This was expressed indirectly by means of interventions that facilitate staff’s everyday clinical practice (e.g. use of visible reminders for performing HH) and address any restraints (e.g. lack of knowledge) that may hinder the accomplishment of the related behaviour.

Interestingly, the distinction of the identified visualisation-centred interventions into dynamic and static and the evident low or no effectiveness of the latter put into question the appropriateness of paper-based interventional approaches that aim to bring about any form of change. This finding was further corroborated by Delphi key experts as well as focus group participants who suggested that such approaches (e.g. posters) are not fulfilling their purpose and are usually ignored by people. PHE (2018) have recently recognised the need to reduce the financial resources on printing leaflets for reasons related to the environmental impact. The findings of this study provide further support for cutting down the associated printing costs. On the other hand, active forms of visualisation that include the provision of feedback to healthcare staff have the potential to lead to effective and sustainable results. Such interventions as found in IR2 were of various forms ranging from HH device scanners and training tablet applications to use of video auditing and laboratory simulation.

7.3.3.1 The importance of the structural aspects of visualisations

The study did not only provide a detailed account of what visualisation types exist in the field but has also examined how visualisations are used in terms of their structural aspects. For example, the importance of receiving feedback on the individual or team level on behaviour performance (e.g. how well the HH technique is performed by the individual, the HH compliance across a hospital unit) or other aspects within a healthcare system affected by behaviour (e.g. spread of infections) was additionally supported in Phases 2 and 3 as a means to intervention effectiveness. Hysong et al. (2006) highlighted the value of auditing and providing feedback and its contribution in establishing safety improvement. The authors proposed an 'actionable feedback' model based on the provision of timely (i.e., in real time using electronic monitoring system), individualised (e.g. formation of teams to identify barriers, set goals, plan interventions and teach staff), non-punitive (i.e., identification of 'positive deviants' for leadership and no exclusion of individuals) and customisable (i.e., staff decide frequency, type and methods for feedback) feedback which led to improved adherence to clinical practice guidelines. The model's four components lend support to the findings of the current research in that the provision of direct feedback needs to take place regularly and in real time as was highlighted especially in Phases 2 and 3, the formation of tailored interventions is key considering potential barriers in the conceptualisation of an interventional strategy as emerged across all three phases, a supportive and guiding and by no means punitive leadership or management approach is needed as it was highlighted in phase 3 and a participatory approach that enhances healthcare staff's voice is vital as it emerged from all three phases.

A systematic review by Lee et al. (2019) sought to determine the effectiveness and identify the core component of IPC programmes in long-term care facilities. The authors suggested that monitoring and feedback along with education should be integral components of any IPC intervention aiming to achieve behaviour change in healthcare staff. They, also, noted that visual approaches can facilitate the success of such interventions especially when the targeted healthcare staff lack expertise in infection control. Finally, monitoring and ongoing feedback was suggested to be particularly beneficial when aiming to address infection prevention as HAIs surveillance results can help staff be more aware of the relationship between infection and IPC practices (Lee et al. 2019).

7.3.3.2 Deciding what visualisation approach to use

The decision of what visualisation approach to use can be seen as a conjunction of multiple considerations. For example, preliminary questions should be taken into account such as:

- *'What is the intervention aiming to achieve?'*
- *'Is the intervention targeting the individual or team level?'*
- *'Are there available financial resources and equipment?'*
- *'What is the intended behaviour change strategy to be adopted?'*

For example, interventions aiming to promote HH may be benefitted by more personalised visualisation approaches as in the case of a HH scanner device where the individual can receive instant and personalised feedback on how well s/he performed the HH technique. However, the cost in this case may be prohibitive and thus other alternatives may be considered. For example, the use of video monitoring followed by personal or team feedback may be a cost-effective visualisation approach towards improving HH and IPC practice. A similar example as identified in IR2 is the use of video reflexive ethnography which involves the video recording of the interaction between healthcare staff and patients followed by team discussion to identify areas in IPC practice than can be improved (Wyer et al. 2017). Video reflexive ethnography is a visualisation approach that provides support to the key role and active involvement of the public (patients and relatives) in the proposed 'change process' in IPC as mentioned previously in this section.

With reference to the behaviour change strategy, the study by Wyer et al. (2017) seems to have adopted a Normative-Re-Educative change approach (see Chapter 4, section 4.4.3.2). An Empirical-Rational change approach may, also, be influential as in the case of simulated patient scenarios using hand gel and black light to visually depict the spread of pathogens in space (e.g. Pope et al. 2014). Although, there is high value in both of the aforementioned two change approaches and it is challenging to favour any of the two it seems that the third change approach proposed by Chin and Benne (1985) namely, Power-Coercion may be the least preferred for a visualisation-centred intervention. This is assumed by the mixed findings on the studies adopting this approach in relation to the intervention effectiveness. Importantly, a Power-Coercion approach would seem to hamper the establishment of an accepting culture as well as being opposed to the value of leadership and management that is supportive towards, and empowering healthcare staff.

7.3.4 Combining theory and visualisation as a pragmatic approach

Another important perspective that the current study offers is that the explicit combination of theory and visualisation should be seen as a considered decision which involves pragmatic aspects. As seen in the introductory Chapter adopting a strong theoretical basis when developing behavioural interventions has been acknowledged as a strong element for the success of visual interventions (Murray et al. 2016). However, the range of theories and visualisations identified in this study allows to revisit existing propositions about theories of visualisation. For example, Williams et al. (2012) described a worked example of a lifestyle intervention targeted to enhance patient involvement among people with increased cardiovascular risk. According to the authors the use of images in their study stemmed from cognitive science with specific reference to emotion and cognition as behavioural determinants. Acknowledging that the development and implementation of a theory-based intervention employing visualisation is a step-wise and iterative process (i.e., theory identification, development of visual narrative, visual rendering and concepts and assessment of interpretation and impact) the authors adopted the MRC Framework for the development and evaluation of complex interventions (Craig et al. 2008). Despite the justified selection and underpinning rationale of this approach, Williams and colleagues noted that the adopted Framework and its constituent elements should be seen as a flexible guide for other researchers in the field of behaviour change and not as a definitive 'to do list'. In addition, they strongly suggested that the role of patients in the process of intervention development and implementation in pertinent healthcare contexts should be enhanced in future research.

The above points mirror important insights gained in the current study. Firstly, they reflect the wide range of theoretical approaches that exist and may highlight that even national and highly rigorous theoretical approaches may not be seen as a definitive underpinning for any interventional solution. In fact, the current study has proposed specific categories of theoretical approaches that may be more beneficial for particular intervention development scenarios. Secondly, Williams et al.'s (2012) worked intervention example emphasises the role of participatory approaches and this tightly links to the findings of the current study regarding the value of co-design and co-development including primarily the active involvement of healthcare staff. Taken together, these points emphasise that the study as a whole is an exploratory and mapping one. This is expressed mostly by exploring situations where visualisations are thought to work (i.e., distinction of systems-wide and focal interventions) in the specific context of theory and less so by exploring the mechanisms of visualisation in detail or solving how visualisation works.

Williams et al. (2012), also, made an important point pertaining to the visual rendering of the intervention's narrative and concepts in relation to theory (i.e., modelling the 'look' stage). Specifically, the authors recognised that the optimal process through which theory and its concepts can be incorporated into visual or audible form is not clear at all. This notion was based on the identification of theoretical approaches and concepts from a range of academic disciplines pertaining directly to visualisation (e.g. colour theory, aesthetics, computer-based art). However, it was evident that overlapping ideas and concepts existed amongst them along with an absence of inter-disciplinary dialogue. The importance of addressing the IPC and HAIs challenge via multidisciplinary perspectives has been strongly highlighted in the current study. This was expressed by the range of theoretical approaches and visualisations identified in IR1 and IR2, as well as the range of healthcare professionals and academics who participated in Phases 2 and 3. Moreover, the findings of this study moved beyond exploring theories from cognitive science and image-based visualisations as in Williams et al. (2012) study. The current study has thus moved towards addressing Williams et al.'s call and provides an initial multidisciplinary mapping of the concepts of theory and visualisation. This potentially offers a helpful evidence-base for researchers working in healthcare applied areas intending to engage with intervention development and implementation explicitly combining theory and visualisation.

Lending further insights to the findings of the study was a paper by Jones and Petrie (2017). The authors proposed the use of 'active visualisation' to increase adherence to anti-retroviral therapy and pre-exposure prophylaxis amongst patients with human immunodeficiency virus. Jones and Petrie defined active visualisation as any visual form aiming to represent the internal processes of the illness in a dynamic manner such as physical demonstration of the illness, smartphone applications or computer modelling. From a theoretical perspective, the use of such visualisations was particularly beneficial in delineating patients' medication beliefs and their illness perceptions. According to the authors active visualisation facilitate patients' abstract thinking about the illness by rendering the related intangible procedures easier to understand (Jones and Petrie 2017). The term of active visualisation that the authors coined resembles what has been described in the current study as dynamic visualisation. The above study example thus tends to support the findings of the current research and the use of dynamic forms of visualisation in the IPC and HAIs context. Such forms of visualisation may be particularly beneficial in the context of IPC and HAIs as pathogens themselves as well as the consequences of acquired infections are not readily visible to the naked eye.

The importance of theory has, also, been highlighted in visual health communication as a means of developing and refining health communication efforts (McWhirter and Hoffman-Goetz 2014). Specifically, the systematic review by McWhirter and Hoffman-Goetz aimed to identify visual communication theoretical approaches in the field of skin cancer and tanning research. The authors defined visual communication as any messages optically stimulating in nature and further noted that visual images may influence attention, recall and better understanding of health information along with health behaviours (Houts et al. 2006; McWhiter and Hoffman-Goetz 2014). Interestingly, only 1 of a total 47 included studies directly reported a visual communication theory (i.e., theory targeted at the visual used from a perception point of view) as a guiding framework. This was based on the five Gestalt rules of grouping (i.e., proximity, similarity, continuity, closure, and connectedness) and in relation to how images are recognised and analysed by the human brain (Banerjee 1994). Of the remaining included studies almost 40% adopted non-visual communication theories stemming from primarily health psychology and health education (e.g. HBM, SCT, TPB). Given the calls for greater attention to the use of visual images in health promotion (Entwistle and Williams 2008) and the absence of visual communication theories has been described as worrying by McWhiter and Hoffman-Goetz (2014).

The above concern has been reflected in the current study as no visual communication theory was explicitly reported or informed any of the studies in Phase 1. Interestingly, one of the statements presented in the Delphi study pertained to the 'shape of objects when developing interventions' (see table 5.9 in Chapter 5) however no consensus was reached in either intervention scenarios as to its usefulness. This outcome may have several interpretations. Firstly, it may be the case that the way the statement was presented did not help key experts fully comprehend that the 'object' referred to the actual visualisation-centred intervention and its physical properties (e.g. shape, colour, size). Secondly, it may reflect disciplinary solitudes in that visual communication is perhaps distanced from health communication. Thirdly, key experts with relevance to adjacent research fields (e.g., arts and design) were very few and outweighed by experts in more traditional behaviour related disciplines (e.g. psychology, nursing, medicine). Last, visual communication is a vast research field (Moriarty 1997) and may have rendered the conceptualisation of the perceptual aspects of visualisation interventions as inaccessible or less helpful especially for experts from other fields. Despite the absence of expert agreement, visual communication theory may be an area of scrutiny in future research in the IPC and HAIs context.

7.4 Recommendations

The recommendations presented in this section directly reflect the findings from all three Phases and in consideration of pertinent evidence from the literature. The findings from the Delphi study in particular have provided a strong basis upon which to develop the suggested recommendations. Specifically, the results of this study indicate that two major intervention development approaches emerged and should be considered when combining theory and visualisation in behavioural interventions in the IPC and HAIs context. The two approaches pertain to the development of systems-wide and focal interventions, respectively. The first approach is linked with behavioural changes targeted across the whole professional population of a healthcare institution usually aiming to decrease infection rates. The second approach is linked with behavioural changes targeted at the individual or team level usually aiming to improve HH. In this section a core set of recommendations are presented first that summarise emergent principles for researchers and clinicians to consider (section 7.4.1) followed by subsequent suggestions reflecting possible avenues for further research and application (section 7.4.2).

7.4.1 Core set of recommendations

A core set of eight recommendations are presented below that summarise emergent principles for researchers and clinicians to consider. These are presented schematically (figure 7.2) and textually

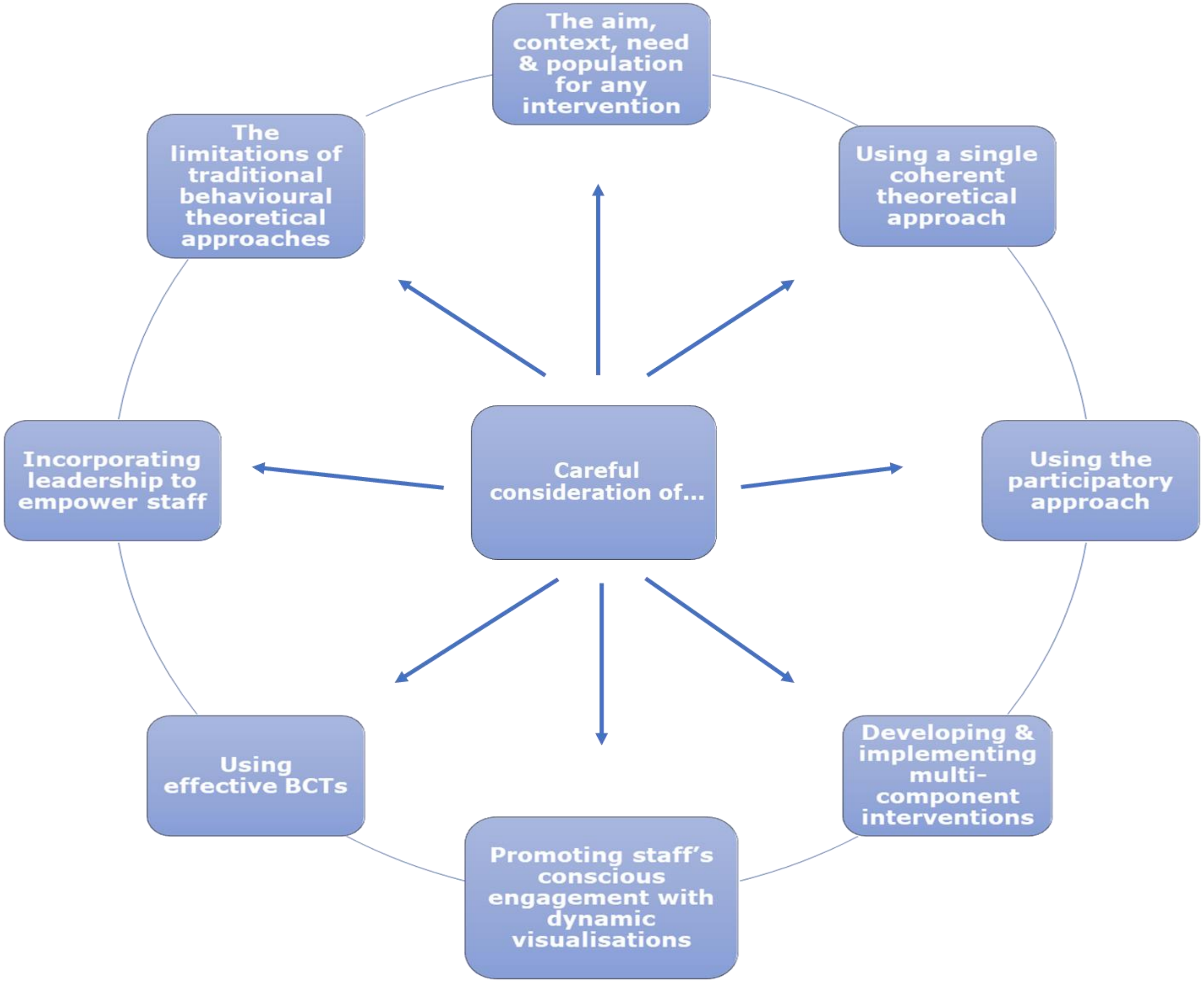

Figure 7.2 Schematic representation of the core set of recommendations

Recommendation 1: Consider carefully the aim, context, need and target population for any interventions, comprehending that one size does not fit all and attending to endogenous and exogenous factors that may influence the effectiveness of interventions and their sustainability. Based on the study findings the intervention scenarios developed and presented herein may offer a fruitful starting point to address the above.

Recommendation 2: Consider carefully the potential value of basing an intervention on one coherent theory, model or framework, with particular regard to participatory methodologies such as co-design. The use of a single theoretical approach to guide the intervention would potentially be more appropriate than use of multiple theories.

Recommendation 3: Consider carefully the selection of a single theory that incorporates participatory approaches actively involving in this case healthcare staff in intervention development and implementation. Although the underpinning mechanism of such involvement was not a primary focus of the study, developers need to work closely with healthcare staff as well as the management level to facilitate this process. This might involve, for example, bridging the gap between the staff's strict work schedules and the staff's time commitments for such an involvement.

Recommendation 4: Consider carefully the potential application of interventions comprising multi-component interventions. This is believed to be particularly beneficial when various visualisations are used within an interventional approach with a range of options available for both scenarios (see figure 7.3 for indicative suggestions).

<u>Recommendation 5:</u> Consider carefully the potential of interventions involving staff in consciously engaging with relevant dynamic visualisations.

<u>Recommendation 6:</u> Consider carefully the potential of involving recognised effective BCTs such as the provision of feedback on behaviour and its outcomes and restructuring the environment. The explicit reference of BCTs in the recommendations mirrors the concept's nature as being the 'active ingredients' and integral component of pertinent interventions.

<u>Recommendation 7:</u> Consider carefully the potential of leadership as a means to motivate and positively influence healthcare staff. Leadership at all levels and throughout the course of an interventional approach appears to have a strong facilitatory role and needs to be incorporated in such interventions. Although there are various leadership styles, it is recommended that leadership styles aiming to empower healthcare staff may be the most appropriate.

<u>Recommendation 8:</u> Researchers and clinicians need to be mindful, however, of the limitations of traditional behavioural theoretical approaches in a field where ecologies of practice are complex and influenced by various factors such as social, political and economic ones.

7.4.2 Possible avenues for further research and application

This section offers possible avenues for further research application reflecting the aforementioned two intervention scenarios and may be of direct interest to researchers and clinicians or infection control teams (section 7.4.2.1) and policy makers (section 7.4.2.2). These avenues represent examples of some possible aspects for future research suggesting two potential intervention structures (section 7.4.2.1).

7.4.2.1 Recommendations for researchers and clinicians or infection control teams

The strongest finding that involves the combination of theory and visualisation is reflected on the foundational basis of figure 7.3 according to which participatory theoretical approaches (e.g. co-design) and dynamic forms of visualisation need to be combined irrespective of the intended intervention scenario. Upon this perspective researchers and clinicians or infection control teams are provided with a tentative and flexible list of options related to the combination of theory, visualisation and BCTs. The figure does not represent a definitive and rigid list of options to be combined but a flexible range of options that were found to have a strong potential across the three research Phases. That said, other combinations may be beneficial for researchers and clinicians or infection control teams engaging in intervention development and implementation. Findings from the related studies of this research can thus offer further insights as to potential combinations (i.e., Chapters 3, 4, 5 and 6).

One of the first decisions that intervention developers need to take is whether the intended intervention is targeted at the institutional (i.e., systems-wide) or individual/team level (i.e., focal), considering at the same time what the intervention is aiming to achieve. Based on this decision various options exist as to the combination of theory, visualisation and BCTs. As can be seen in figure 7.3 some of these options overlap between the two intervention scenarios and others offer distinct solutions. For example, in terms of use of theory QI approaches may be valuable to be adopted in both intervention scenarios. Similarly, in terms of use of BCTs, the provision of feedback on behaviour and its outcomes, as well as instructions on how to perform behaviour, may be beneficial for both systems-wide and focal interventions.

In light of the core set of recommendations and considering figure 7.3, potential intervention structures are provided below in relation to the two intervention scenarios.

- **Potential structure for a systems-wide intervention**: a multi-stage theoretical approach such as the MRC Framework for complex interventions or the COM-B Framework or a QI approach (e.g. PDSA cycles) can be used to guide intervention development and implementation and further guide the decision-making process. This can be combined with various visualisation options such as smart phone applications, video mapping to represent pathways of infection, and demonstration of transmission and pathogen reservoir. The intervention can be further enriched by use of specific BCTs such as feedback on behaviour and its outcomes, instructions on how to perform the behaviour, restructuring the environment and use of action planning.
- **Potential structure for a focal intervention**: the use of Learning Theory such as through experiential learning (e.g. Kolb 2014) or a more traditional psychological approach such as the PRECEDE Framework or a QI strategy may be particularly beneficial for this type of interventions. The use of such theoretical approaches can be further enhanced by used of visualisations pertaining to lab simulations, demonstration of transmission and pathogen reservoir, visualisations of pathogens, videos that include modelling the intended behaviours (e.g. hand washing), and visual reminders. Specific BCTs particularly beneficial for this type of intervention may be the provision on feedback of behaviour and its outcomes, instruction on how to perform the behaviour, habit formation and behavioural practice or rehearsal.

Finally, it is important that intervention developers take justified decisions for the selection of theory and visualisation or any other aspect of the developed and implemented intervention. Crucially, this needs to be clearly articulated in any disseminated document to help other researchers comprehend the underlying processes and facilitate their decision. This is envisaged to support the evidence base and lead to further advancements in the field.

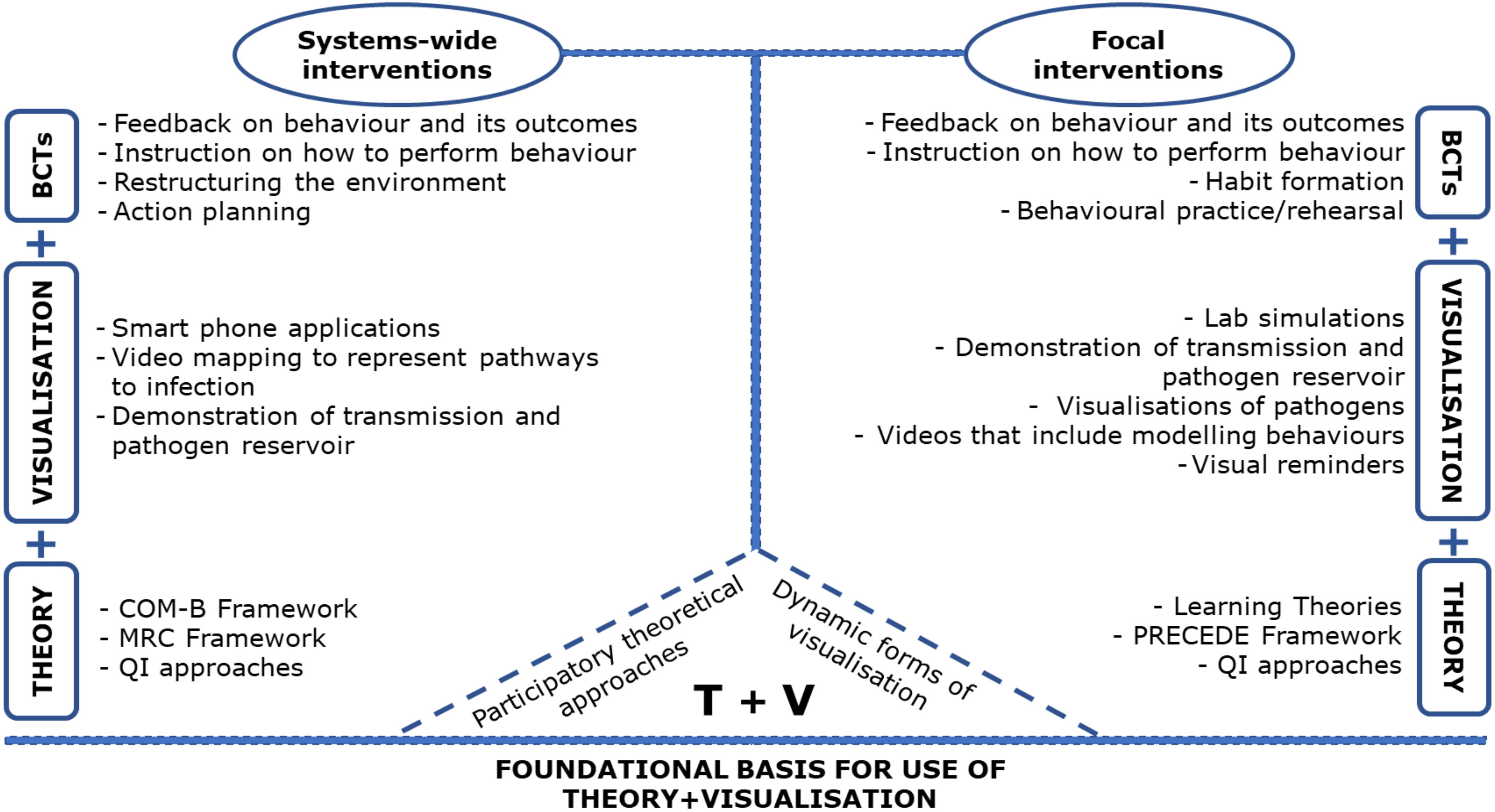

Figure 7.3 Recommendations for the development of behavioural intervention in the IPC and HAIs context combining theory and visualisation

7.4.2.2 Recommendations for policy makers and the management level

Considering the ever-changing healthcare environment and the numerous demands that exist within the hospital context (e.g. time constraints, availability of resources and staffing issues) the above recommendations need not be seen in a vacuum. As such, it is suggested that the role of policy makers (e.g. at a government level) and the management level in facilitating intervention developers and ensuring intervention success is very important.

Part of the evidence reported in this thesis indicates that the use of static forms of visualisation, predominantly the use of paper-based visualisations such as posters are of low effectiveness especially when compared to dynamic forms of visualisations. This finding emerged in all three Phases yet the use of posters, and leaflets remains very prevalent as a means of interventional solutions across a range of target groups. For this reason and considering the related high costs for such approaches (e.g. for printing and distribution), policy makers and the management level should re-consider the usefulness of such static forms of visualisations (e.g. by reducing their use and related printing costs) with the ambition to change staff's behaviours in the IPC and HAIs context. That said, dynamic forms of visualisation should be embraced more and included not only as part of a continuous strategy in clinical practice but also used in induction, training and academic purposes.

Another recommendation is rooted in the focus group study and relates to the need for healthcare staff to be given voice in the decision and policy process. For example, nursing staff noted the consequences that harsh soap has for their skin and this is a concern that needs to be taken into account when attempting to enhance IPC practices. This is an important finding, as it indicates that inclusion of all healthcare staff in such processes highlights their crucial role in IPC practice and empowers them as actors of actual behaviour change. Further extending this recommendation, the factors that hinder staff's clinical practice in relation to IPC need to be identified and considered continuously by policy makers and the management level. In concordance with the above point, the inclusion of physicians in the IPC process such as observations and audits need to be enhanced. Currently, it appears that nursing staff are predominantly shouldered with this responsibility. Conversely, physicians appear to be less compliant with hygiene policies compared to other healthcare professional groups such as nurses (Squires et al. 2013). Thus, engaging them actively in this process would potentially let them act as role models for other physicians and enhance their participation in IPC practices in a more effective manner. The establishment and promotion of effective leadership is another area to be embraced by policy makers and the management level. As seen in the study's research phases effective leadership and taking personal responsibility and accountability regarding IPC practices are key contributors. The explicit incorporation of effective leadership should be a direct consideration of intervention developers but needs to be facilitated by policy making and management perspective. It is, therefore, recommended that leadership and training of leadership skills should be a priority specifically for nursing academic curricula and as part of healthcare staff's continuing personal development.

7.5 Strengths and weaknesses of the study

Strengths and weaknesses for the specific methods chosen are discussed in the corresponding chapters 3, 4, 5, and 6. With regard to the overall research study, however, there are further strengths and weaknesses that need to be mentioned. As a notable strength, the study provides a unique contribution to the current knowledge base regarding the use of theory and visualisation in IPC-related interventions by extensively exploring the literature and illuminating the perspectives of key stakeholders. This contribution is reflected across the three research phases of the study which can be seen both as standalone study pieces but also as a unified entity in a triangulated manner.

By utilising a pragmatic philosophical paradigm, the study benefitted from embracing different data collection methods using integrative literature reviews, questionnaires within a Delphi study and interviews within focus group discussions. Within the pragmatic paradigm the study is underpinned by both a problem-solving and action-based approach to inquiry (Long et al. 2018). These approaches reflected the ambition of the study to explore how healthcare staff can be best facilitated by the optimal combination of theory and visualisation within the complexities of the healthcare system. Another strength of the study lies in the axiology of pragmatism and specifically in relation to the important role of values stemming from various perspectives in interpreting the findings (see Chapter 2 table 2.1). For example, focus group participants highlighted on some occasions their disagreement with Delphi key experts' opinions as not being able to fully comprehend the reality, priorities and context of their clinical practice. Similarly, in depth qualitative feedback in the Delphi study reflected the different beliefs and values of the very different disciplinary backgrounds of the participants. Thus, the study design is strong on this respect and overall handles the simplistic 'biased vs non-biased' debate on reality by embracing the notion that there are different ways of seeing the world. This has been recognised in the current study as there are many different ways of seeing the world in terms of theory and visualisation and reflected by the use of triangulation approaches. The adopted pluralism of methods enabled the researcher to explore the field from multiple perspectives and thus build an understanding of the whole process and stakeholders' needs. Towards this direction, the use of the Delphi study and the focus group discussions strengthened the study and offered rich data on stakeholders' opinions, perspectives and experiences on issues related to theory and visualisation in the IPC context.

In terms of the generalisability of the study findings and potential issues with qualitative research (see Chapter 2) caution needs to be exercised especially when interpreting the Phase findings. For example, the relative limitations of the IR method have to be acknowledged especially when comparing levels of effectiveness of the included studies. This may be explained by the inclusive character of the IR method which allows for the simultaneous consideration of experimental and non-experimental primary studies. As such, a systematic review or a meta-analysis could have been helpful if a more limited focus on statistical conclusions about effectiveness had been seen as appropriate (Whittemore and Knafl 2005). Despite this limitation, the IR method as the broadest type of research review served the primary aim of the study in establishing breadth in mapping a diverse and previously unexplored field.

Moreover, with regards to the Delphi study, it has been suggested that the selection of a Delphi expert panel needs to be randomly sampled and representative in order to achieve generalisability of the findings (Williams and Webb 1994) or that a large panel can ensure reliability and validity (Murphy et al. 1998). However, opposing arguments exist in that generalisability of the findings should not viewed from a statistical perspective but in consideration of the nature and experiences of the participating key experts. In the same vein, the size of the expert panel should be determined by the scope of the topic under investigation as well as the availability of relevant expertise. Indeed, the lack of established universal guidelines in the conduct of a Delphi study was highlighted and considered in the relevant Chapter 5 (Powell 2003). Therefore, in order to enhance trustworthiness and amongst other actions taken, key experts inclusion criteria were developed at the outset of the study conceptualisation and a panel of experts from across the world was intended and achieved.

With regard to the focus group discussions challenges with the recruitment process were evident and resulted in establishing continuous communication with gatekeepers. In one case, an initially scheduled focus group discussion had to be cancelled and re-scheduled as no participants attended on at the arranged day of the discussion. Another potential limitation of the focus group study may relate to how faithfully the recruitment process was adhered to by the gatekeepers and participants side. In other words, it is unclear whether participants who expressed an interest to participate (by sending an e-mail to the researcher) did so because they solely read the invitation poster or owing to the gatekeeper or someone else from their department asking them to do so. The latter appears to be a possibility especially following the cancelation of one of the focus groups. Specifically, the researcher in addition to the group gatekeeper contacted several ward managers who indicated that they would ‘release’ one or two nurses the next time the focus group was scheduled for. The focus group study was, also, geographically restricted to Scotland however the current researcher does not believe that the findings would not have been different to the rest of the UK. A justified rationale for the selected NHS Health Boards, number of focus groups, their nature and scope as well as intended group size were all detailed in the related ethics forms (i.e., institutional approval and R&D permission) and explained in Chapter 6.

Overall, specific strategies were adopted to ensure trustworthiness in the study and included triangulation of data and methods, frequent member check as well as the transparent description of the processes involved in each of the three study phases using audit trails as well as maintaining and sharing with the supervisory team detailed research progress logs upon completion of team meetings (Lincoln and Guba 1985; Sim and Sharp 1998; Korstjens and Moser 2018).

7.6 Original contribution to knowledge

A key strength of the overall research is its original contribution to knowledge. Phillips and Pugh (2010) in a handbook for students and supervisors on how to get a PhD, outlined multiple concepts which determine originality in research. Several of these concepts relate to this research. For example, the produced research reflected 'an original synthesis' that has been undertaken, 'an empirical research that has not been done before', 'researching unexplored areas in a discipline' as well as 'provided knowledge in a new way'. More specifically, the two IRs in Phase 1 were conducted as a direct response to the dearth of research evidence on the use of theory and visualisation in IPC-related interventions. This was a crucial decision that reflected the progression of the study as a whole in terms of its conceptualisation and realisation. In other words, a sole integrative or systematic literature review could have been an alternative option explicitly looking at interventions combining theory and visualisation. Even if such an alternative approach would have been robust from a methodological point of view it would have been very limited in terms of any new knowledge and limiting in a research field where there was not even an initial exploration or mapping.

Phase 1 was linked to the overarching aim of the research at that time to develop and pilot-test a theory-based and visualisation-centred intervention. In order to achieve that, it was key to conduct an in depth and systematic exploration of the literature on the above concepts and in light of the fact that very limited research studies existed combining theory and visualisation in the HAIs and IPC context.

The completion of Phase 1 resulted in furthering understanding of the nature of theory-based and visualisation-centred interventions that have been implemented, their structure and application as well as whether they have been effective. Consequently, this led to increasing the knowledge base in the field. Importantly, by the end of Phase 1, the overarching aim of the research was modified as to explore in depth the concept triad of 'HAIs-theory-visualisation' with the view of developing pertinent recommendations by involving key stakeholders and seeking for their opinions and perspectives. Therefore, Phases 2 and 3 were developed to add more depth in terms of developing behavioural interventions that best combine theory and visualisation. For example, this depth was achieved by presenting to Delphi key experts' theories and visualisations not initially reported by them (i.e. in round 1) and were asked to consider them along with the statements that emerged directly from their responses. In terms of the identified theories, a range of them were included for consideration that moved beyond the individual or group behaviour thus allowing for further enrichment by a wider perspective. This was a novel contribution in the context of the current published literature and as evidenced in the two IRs, the questions that emerged were more likely to be answered by people involved in intervention development and implementation. To the author's best knowledge, the contribution of the Delphi key experts and the focus group healthcare staff with a focus on the concept triad of 'HAIs-theory-visualisation' has not received scrutiny before.

Originality in the current research was, also, demonstrated in 'using a particular technique in a new way' (Phillips and Pugh 2010). Specifically, both the Delphi and focus group technique that where utilised adhered to overarching principles as to their conduct but also incorporated elements of novelty and creativity. For example, the second round of the Delphi study was underpinned both by the responses of key experts in round 1 but also by part of the findings of the two IRs in terms of identified theories and visualisations. This ensured that those theories and visualisation approaches identified in the two IRs and not mentioned by key experts in round 1 were presented to be rated or ranked as appropriate. Also, rounds 2 and 3 of the Delphi study included the development of two intervention scenarios reflecting the nature of experts' responses in round 1. Anchoring the responses on one of the two scenarios the study thus offered a novel structural perspective and contributed towards knowledge originality.

Finally, with the research 'being cross-disciplinary and using alternative methodologies' (Phillips and Pugh 2010) the originality of the research was further enhanced. This was evident on the cross-disciplinary character of the research team, the external advisors who provided feedback at various stages of the process as well as the participating Delphi experts and focus group participants. The variety and inclusion of these individuals further advanced the originality as it ensured rich perspectives from nursing, psychology, health services, medicine, arts and design, engineering were considered and represented throughout the research.

7.7 Impact of the research

According to the Research Councils UK (RCUK) (2019) research impact is classified into academic impact and economic and societal impact. The impact of the research is predominantly academic with societal and economic impact being also evidenced indirectly.

The impact of this research is also discussed in relation to its key findings. This mirrored the Economic and Social Research Council's (ESRC) (2019) recommendations for reporting on the impact of completed research. ESRC highlights four sections that need to be addressed namely, 'discoveries or developments through the research', 'original objective', 'ways that findings can be taken forward', and 'sectors that may have an interest on the study findings'.

Discoveries or developments through the research: the current study led to the generation of significant new knowledge on the development of behavioural interventions in IPC using theory and visualisation. As shown in the two IRs (Phase 1), extensive mappings of theory-based and visualisation-centred interventions were achieved with further questions emerging. The latter formed the basis for conceptualising and developing the next research phases. On an interpersonal level, this resulted in the development of the researcher's skills in terms of conducting research based on methods not previously used. In addition, outputs from the research were disseminated on a continuous basis in national and international conferences including poster and oral presentations. A rewarding development of this keen engagement was the prize-winning oral presentation of the IR about visualisation-centred interventions denoting the potential interest in, and significance of this research to the research community.

Original objective: regarding the original objective of exploring the field of IPC and HAIs in depth with a view to developing evidence-based recommendations for designing behaviour change interventions that combine theory and visualisation was met.

Ways that findings can be taken forward: the three generated research phases have enhanced the establishment of an evidence-base on theory and visualisation in IPC behavioural interventions. This should be utilised as the catalyst for further exploration and food for thought for other academics and researchers interested in IPC research or adjacent research fields. Antimicrobial resistance may be an example of pertinent research area that has been receiving much scrutiny with increasing calls to address it through innovative and cross-disciplinary ways (UKRI 2019).

Sectors that may have an interest on the study findings: the findings of this research may be of interest to a range of sectors including nursing, health psychology, infection prevention and control, and implementation science.

7.8 Reflections on the process of the study

My engagement with this research has been an intense learning experience and a 'journey' that I could perceive its significance only towards its end when the 'destination' was visible. This somewhat poetic terminology that other successful PhD candidates often use to describe their doctoral experience caused to me mixed feelings especially at the start of my PhD study both in terms of excitement and anxiety. As the time was passing, though, and the research was progressing, the anxiety and related pressures were substituted with a deep feeling of joy for learning and self-discovery.

The research proposal that I developed at the beginning of my candidature (in 2015) was entitled 'The mind's eye in healthcare-associated infections'. This focus reflected the nature and scope of the advertised PhD studentship that was conceived by the supervisory team as an intervention and evaluation study and was further imbued with my interest in the concept of behaviour change and intention to review and synthesise knowledge from psychology that can usefully inform our understanding and use of visualisation in this context. Related to this I, also, stated in the research proposal document that I intended 'to develop, pilot and evaluate this intervention with a mixed group of healthcare staff' and 'to make relevant recommendations for future development and research'.

For reasons explained in Chapter 2, the doctoral research progressed with the aim to explore the concepts of theory and visualisation in depth with the overarching research question of "how can theory and visualisation best inform behaviour change interventions designed to help healthcare staff prevent and control HAI?". This progression was underpinned by my personal desire to conduct a research study that would be practically helpful and insightful. I believe it is fair to say that this ambition is reflected in the final thesis.

As the final form of my thesis in terms of structure and research Phases became clear, I developed a strong interest in directly exploring the opinions and perspectives of stakeholders involved in the context of IPC within the pragmatic philosophical tradition. Apart from the insights gained by the participating stakeholders, what was particularly rewarding for me was the process of engaging with those individuals, communicating my research interests and ideas and receiving supportive comments as to the value of this area of research. In light of my psychology background and its strong positivist-led approaches, the above engagement highlighted to me the value of qualitative approaches which at the time I commenced my research were not readily available in my toolbox. As a result, I further enhanced my skills in qualitative approaches and broadened my horizons. I, also, found myself spending days or even weeks scrutinising research areas and devoting time to find specific answers. Following personal reflection as well as advice received by the supervisory team and other academic colleagues it became apparent to me that any methodological decisions should be justified and clearly articulated.

The process of the study was, also, strongly determined by several opportunities I had, as for example to receive training related to the research approaches I implemented, to meet and converse with other academics and fellow students and exchange ideas, as well as to present my ongoing work in national and international conferences and get actively involved in extracurricular activities. Despite there were periods of time reflecting some puzzlement they proved as the catalyst for me to move on and overcome any negative emotions and thoughts I had. Possibly living the good and the bad moments of the PhD journey to the fullest is what made the journey itself more valuable to me.

7.9 Conclusion

This thesis explored the concepts of theory and visualisation in depth and provided insights as to how can the two best be combined for the development of pertinent interventions in the IPC context. This exploration has resulted in the development of recommendations for individuals involved in intervention development and implementation as well as policy makers and healthcare managers. The analysis of each of the three phases and the input of the participating stakeholders provided a significant development in the field embracing an innovative, and cross-disciplinary approach.

This work has consequently the following qualities:

- significance for academic practice and research regarding the generation of new knowledge
- value for academics and researchers in relation to the adopted methodological approach embarking from the philosophical paradigm of pragmatism
- relevance for healthcare staff and the healthcare system via the development of pertinent interventions

Based on the above, this doctoral research makes a direct academic contribution and provides the basis for further explorations and advancements in the field of IPC and HAIs.

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Appendices

Appendix 1 QATSDD tool
Appendix 2 CASP RCT checklist
Appendix 3 Studies excluded in IR1 after full-text screening
Appendix 4 Description of theories identified in IR1
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Appendix 6 QI-MQCS tool
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Appendix 8 '4-point ruler' used for mapping IR2 studies
Appendix 9 Invitation e-mail to Delphi key experts
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Appendix 11 Round 1 online questionnaire of the Delphi study
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Appendix 14 Round 3 questionnaire of the Delphi study
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Appendix 16A Focus group topic guide for infection control teams
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Appendix 17 Invitation poster used to recruit focus group participants
Appendix 18 Participant information sheet in focus group discussions
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Appendix 20 Example of coding participants' extracts for question 1 of the topic guide for both focus group types

Appendix 1 – QATSDD tool

Study to be appraised:

Criteria	*0 not at all*	*1 very slightly*	*2 moderately*	*3 complete*	*Comments*
Explicit theoretical framework					
Statement of aims/objectives in main body of report					
Clear description of research setting					
Evidence of sample size considered in terms of analysis					
Representative sample of target group of a reasonable size					
Description of procedure for data collection					
Rationale for choice of data collection tools					
Detailed recruitment data					
Statistical assessment of reliability and validity of measurement tool(s) (Quantitative only)					
Fit between stated research question and method of data collection (Quantitative)					
Fit between stated research question and format and content of data collection tool e.g. interview schedule (Qualitative)					
Fit between stated research question and method of analysis					
Good justification for analytical method selected					
Assessment of reliability of analytical process (Qualitative only)					
Evidence of user involvement in design					
Strengths and limitations critically discussed					

Criteria	0 = Not at all	1 = Very slightly	2 = Moderately	3 = Complete
Explicit theoretical framework	No mention at all.	Reference to broad theoretical basis.	Reference to a specific theoretical basis.	Explicit statement of theoretical framework and/or constructs applied to the research.
Statement of aims/objectives in main body of report	No mention at all.	General reference to aim/objective at some point in the report including abstract.	Reference to broad aims/objectives in main body of report.	Explicit statement of aims/objectives in main body of report.
Clear description of research setting	No mention at all.	General description of research area and background, e.g. 'in primary care'.	General description of research problem in the target population, e.g. 'among GPs in primary care'.	Specific description of the research problem and target population in the context of the study, e.g. nurses and doctors from GP practices in the east midlands.
Evidence of sample size considered in terms of analysis	No mention at all.	Basic explanation for choice of sample size. Evidence that size of the sample has been considered in study design.	Evidence of consideration of sample size in terms of saturation/information redundancy or to fit generic analytical requirements.	Explicit statement of data being gathered until information redundancy/saturation was reached or to fit exact calculations for analytical requirements.
Representative sample of target group of a reasonable size	No statement of target group.	Sample is limited but represents some of the target group or representative but very small.	Sample is somewhat diverse but not entirely representative, e.g. inclusive of all age groups, experience but only one workplace. Requires discussion of target population to determine what sample is required to be representative.	Sample includes individuals to represent a cross section of the target population, considering factors such as experience, age and workplace.
Description of procedure for data collection	No mention at all.	Very basic and brief outline of data collection procedure, e.g. 'using a questionnaire distributed to staff'.	States each stage of data collection procedure but with limited detail, or states some stages in details but omits others.	Detailed description of each stage of the data collection procedure, including when, where and how data were gathered.
Rationale for choice of data collection tool(s)	No mention at all.	Very limited explanation for choice of data collection tool(s).	Basic explanation of rationale for choice of data collection tool(s), e.g. based on use in a prior similar study.	Detailed explanation of rationale for choice of data collection tool(s), e.g. relevance to the study aims and assessments of tool quality either statistically, e.g. for reliability & validity, or relevant qualitative assessment.
Detailed recruitment data	No mention at all.	Minimal recruitment data, e.g. no. of questionnaire sent and no. returned.	Some recruitment information but not complete account of the recruitment process, e.g. recruitment figures but no information on strategy used.	Complete data regarding no. approached, no. recruited, attrition data where relevant, method of recruitment.
Statistical assessment of reliability and validity of measurement tool(s) (Quantitative only)	No mention at all.	Reliability and validity of measurement tool(s) discussed, but not statistically assessed.	Some attempt to assess reliability and validity of measurement tool(s) but insufficient, e.g. attempt to establish test–retest reliability is unsuccessful but no action is taken.	Suitable and thorough statistical assessment of reliability and validity of measurement tool(s) with reference to the quality of evidence as a result of the measures used.
Fit between stated research question and method of data collection (Quantitative)	No research question stated.	Method of data collection can only address some aspects of the research question.	Method of data collection can address the research question but there is a more suitable alternative that could have been used or used in addition.	Method of data collection selected is the most suitable approach to attempt answer the research question
Fit between stated research question and format and content of data collection tool e.g. interview schedule (Qualitative)	No research question stated.	Structure and/or content only suitable to address the research question in some aspects or superficially.	Structure & content allows for data to be gathered broadly addressing the stated research question(s) but could benefit from greater detail.	Structure & content allows for detailed data to be gathered around all relevant issues required to address the stated research question(s).
Fit between research question and method of analysis	No mention at all.	Method of analysis can only address the research question basically or broadly.	Method of analysis can address the research question but there is a more suitable alternative that could have been used or used in addition to offer greater detail.	Method of analysis selected is the most suitable approach to attempt answer the research question in detail, e.g. for qualitative IPA preferable for experiences vs. content analysis to elicit frequency of occurrence of events, etc.
Good justification for analytical method selected	No mention at all.	Basic explanation for choice of analytical method	Fairly detailed explanation of choice of analytical method.	Detailed explanation for choice of analytical method based on nature of research question(s).
Assessment of reliability of analytical process (Qualitative only)	No mention at all.	More than one researcher involved in the analytical process but no further reliability assessment.	Limited attempt to assess reliability, e.g. reliance on one method.	Use of a range of methods to assess reliability, e.g. triangulation, multiple researchers, varying research backgrounds.
Evidence of user involvement in design	No mention at all.	Use of pilot study but no involvement in planning stages of study design.	Pilot study with feedback from users informing changes to the design.	Explicit consultation with steering group or statement or formal consultation with users in planning of study design.
Strengths and limitations critically discussed	No mention at all.	Very limited mention of strengths and limitations with omissions of many key issues.	Discussion of some of the key strengths and weaknesses of the study but not complete.	Discussion of strengths and limitations of all aspects of study including design, measures, procedure, sample & analysis.

Appendix 2 – CASP RCT checklist

CASP RCT Checklist	**Yes**	**Can't tell**	**No**
Section A: Are the results of the trial valid? 1. Did the trial address a clearly focused issue? 2. Was the assignment of patients to treatments randomised? 3. Were all of the patients who entered the trial properly accounted for at its conclusion? 4. Were patients, health workers and study personnel 'blind' to treatment? 5. Were the groups similar at the start of the trial 6. Aside from the experimental intervention, were the groups treated equally?			
Section B: What are the results? 7. How large was the treatment effect? 8. How precise was the estimate of the treatment effect?			
Section C: Will the results help locally? 9. Can the results be applied to the local population, or in your context? 10. Were all clinically important outcomes considered? 11. Are the benefits worth the harms and costs?			

The CASP RCT Checklist as presented above is a summarized form of its online version: https://casp-uk.net/wp-content/uploads/2018/01/CASP-Randomised-Controlled-Trial-Checklist-2018.pdf

Appendix 3 – Studies excluded in IR1

Authors, year	**Reasons for exclusion**
Brock 2012	Full-text could not be retrieved
Eigsti 2011	Full-text could not be retrieved
Gould et al. 2010	Systematic review
Huis et al. 2013	Systematic review
Kingston et al. 2016	Systematic review
Srigley et al. 2015	Systematic review
Edwards et al. 2012	Systematic review
Quintard et al. 2010	Written in French
Gould and Chamberlain 1997	No explicit use of theory
Kamsu-Foguem et al. 2014	No explicit use of theory
Pronovost et al. 2010	No explicit use of theory

Appendix 4 – Description of theories identified in IR1

Theories that were the sole point of reference in the reported interventions:

1. PRECEDE-PROCEED model (*n*=2 studies: Aboumatar et al. 2012; Creedon, 2005): The PRECEDE (Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation) – PROCEED (Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development) model (Green, 1974; Green et al. 1980; Green and Kreuter, 1991) is an 8-phased planning model (figure 1) used for creating health promotion interventions. The first 4 phases (Green and Kreuter, 2005, p 205) precede intervention development and implementation to ensure the intervention is suitable to the needs of those people who will use it and refer to:
    - Social assessment (Phase 1)
    - Epidemiological assessment (Phase 2)
    - Educational and ecological assessment of predisposing, reinforcing and enabling factors (Phase 3)
    - Administrative and policy assessment and intervention alignment (Phase 4)

The remaining 4 phases proceed the preparatory stages and include:

- Intervention implementation (Phase 5)
- Process evaluation (Phase 6)
- Impact evaluation (Phase 7)
- Outcome evaluation (Phase 8)

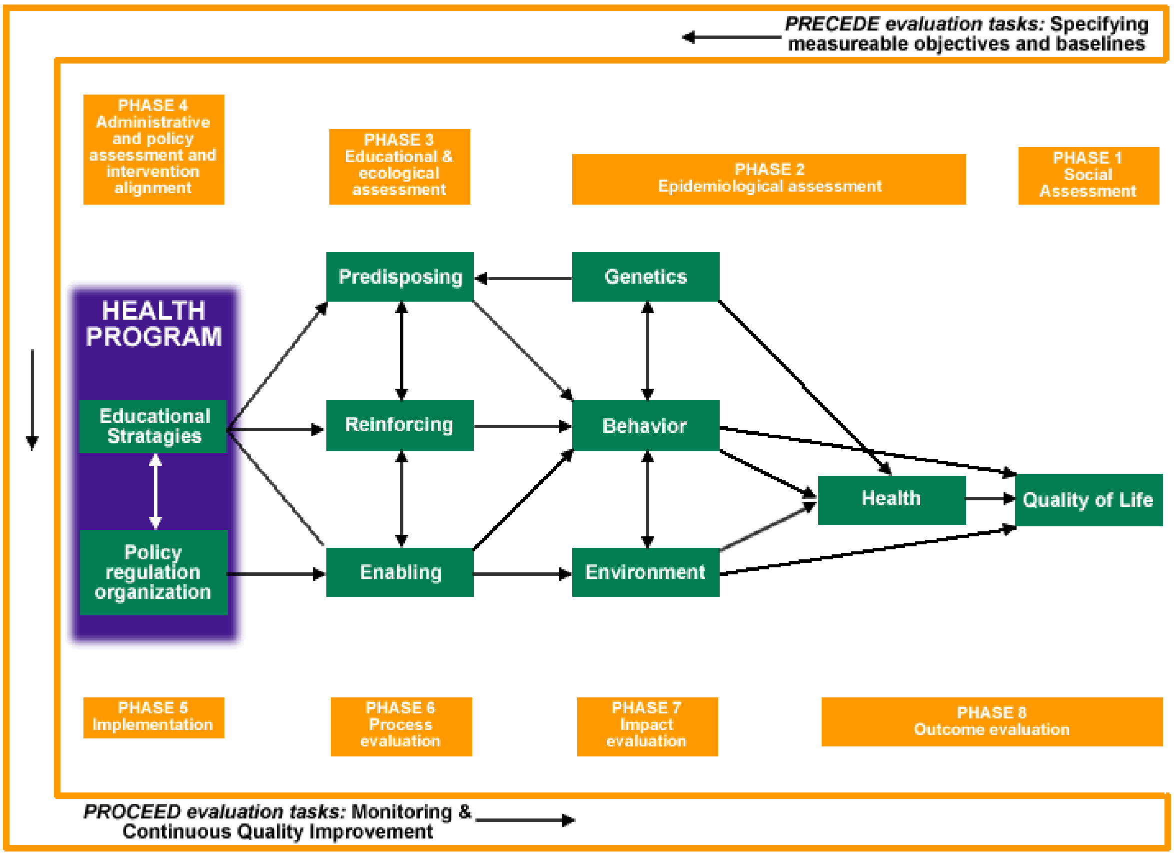


Figure 1. Representation of the PRECEDE-PROCEED model (source: Green and Kreuter, 2005)

The PROCEED-PRECEDE model can be seen as a cyclical process moving from the planning phases (i.e., PROCEED constructs) to the evaluation phases (i.e., PRECEDE constructs) (Kahan et al. 2014).

2. BASNEF model (*n*=1 study: Baghaei et al. 2016); The BASNEF (Beliefs, Attitudes, Subjective Norms and Enabling Factors) was introduced by Hubley in 1993 for comprehending human behaviour in health-related communication. The model departs from the theories of Reasoned Action (Ajzen and Fishbein, 1975) and Planned Behaviour (Ajzen, 1985) having incorporated the Enabling Factors component of the PRECEDE-PROCEED model. According to the model personal beliefs about the consequences of a specific behaviour and the importance placed on each consequence form personal attitudes. The latter coupled with the individual's subjective norms contribute to behavioural intention. Finally, enabling factors (e.g. resources, financial assistance) have to be in place so that behavioural intention is translated to change in behaviour (Lens et al. 2001).

3. Roger's Diffusion of Innovation theory (*n*=1 study: Basinger, 2014): Dated back to 1962, Roger's Diffusion of Innovation theory seeks to explain how an innovation (e.g. a new idea, practice or object) can be effectively communicated across a team over time (Rogers, 2003).
4. Iowa model of evidence-based practice (*n*=1 study: Hanrahan & Lofgren, 2004): The Iowa model of evidence-based practice (Titler et al. 2001) provides a guide for nursing and other healthcare staff and facilitates decision making in relation to day-to-day healthcare practice. The model highlights the importance of evidence-based practice which can be achieved through research and considering the whole healthcare system including patients, healthcare staff, provider and infrastructure (Titler et al. 2001)
5. Sociotechnical systems framework (*n*=1 study: Lewis et al. 2014): This is an approach that explores the interactions between social (i.e., people and organisation) and technical (i.e., physical system and tasks) factors in the workplace considering that the organisational work design can be complex (figure 2). This approach places particular emphasis on the relationship between people and technology in solving problems (e.g. HAIs in the healthcare context) and developing dedicated interventions (Kleiner, 2007).

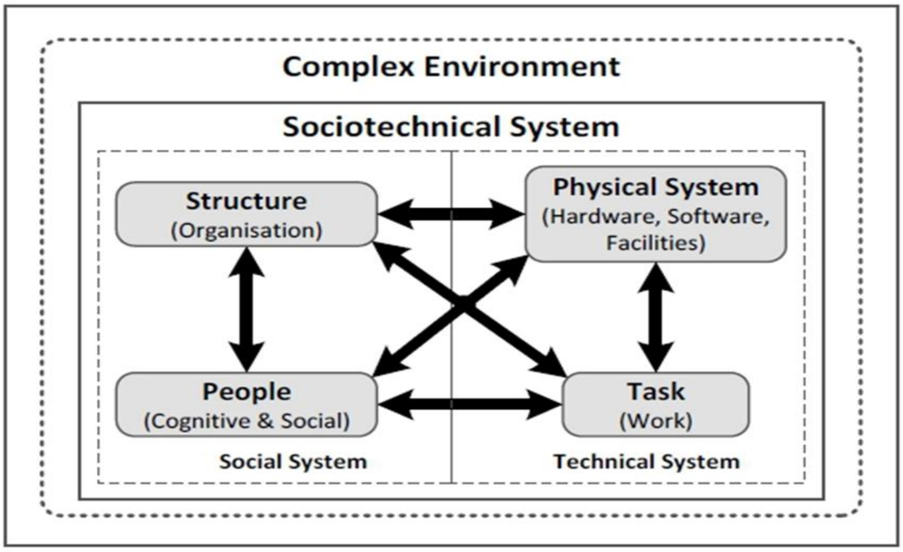


Figure 2. Schematic representation of the Sociotechnical Systems framework (adopted from Bostrom and Heinen, 1977).

6. PDSA cycles (*n*=2 studies: Linam et al. 2011; Pulcini et al. 2007): The Plan-Do-Study-Act cycle is a quality improvement model that is used to bring about positive change within teams through constant learning and immediate

action based on thoughtful research and study (NHS Improvement) (figure 3).

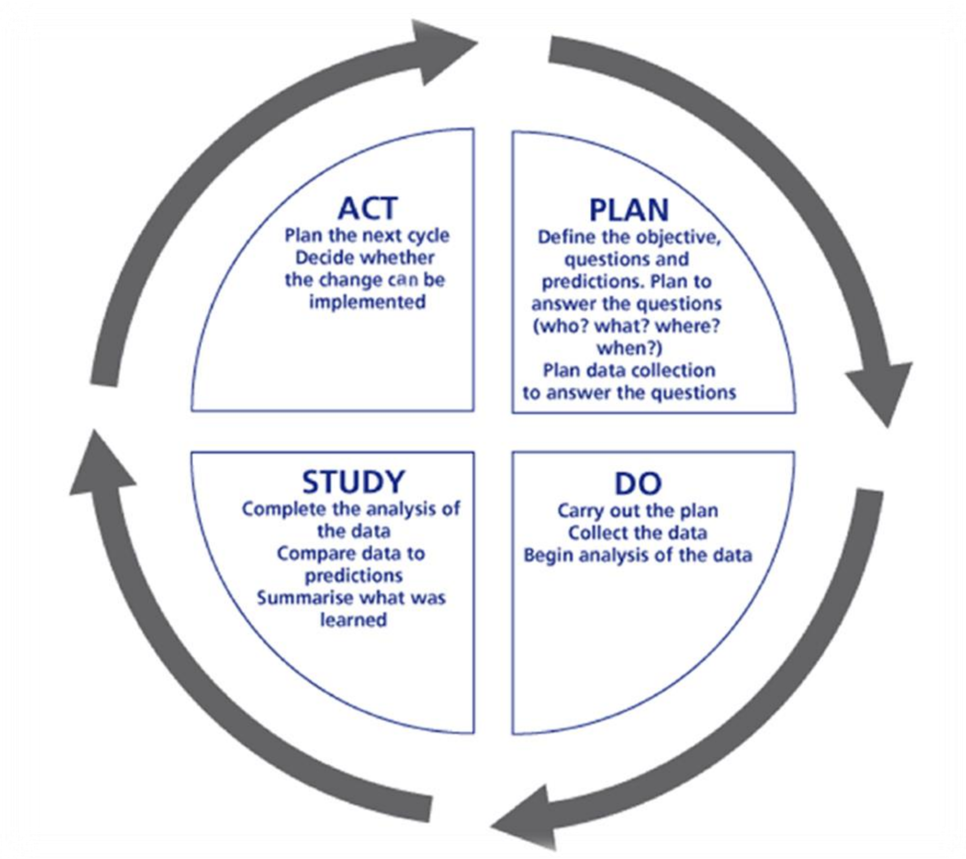


Figure 3. The iterative process of learning and making changes according to the PDSA cycle (adopted from NHS Improvement)

7. Kotter's 8-step change model (*n*=1 study: Su, 2016): The 8-step change model proposed by Kotter (2012) emanates from a leadership and change management perspective. All steps of the model are of equal importance towards initiating successful changes in practice (figure 4). These steps are seen as part of three overarching categories: (i) creating climate for change (steps 1-3), (ii) engaging and enabling the whole organisation (steps 4-6) and (iii) implementing and sustaining change (steps 7-8) (Kotter 2012).

Figure 4. Kotter's 8-step change model

8. 5 moments for HH (*n*=1 study: Martin-Madrazo et al. 2012): Although not a traditional theoretical concept, the 5 moments for HH is a WHO evidence-based and person-centred approach that has been used in healthcare settings as a HH policy guide for healthcare staff. According to the approach healthcare staff should clean their hands in every of the 5 instances (or moments) as shown in figure 5 below.

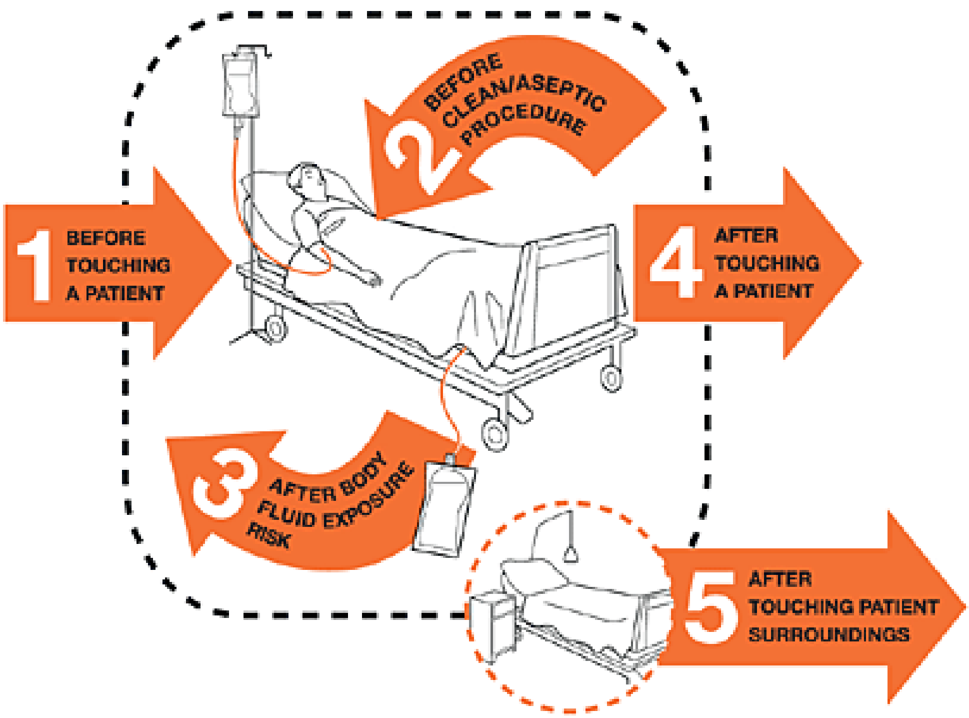


Figure 5. Schematic representation of the '5 moments for HH'

In the remaining 6 studies, a mixture of theories underpinned the implemented interventions as shown below:

1. Huis et al. (2013): social learning theory, social influence theory, theory on team effectiveness, and leadership theory
   Often described as the bridge between the behaviourist and cognitive learning theories, social learning theory (Bandura, 1977) proposes that individuals learn through observation, imitation and behaviour modelling encompassing the concepts of memory, attention and motivation.

   Social influence theory (Kelman, 1958) proposes that an individual's attitudes, beliefs or actual behaviour can be influenced by others. Such a process appears to take place when individuals: accept influence by others (i.e., concept of compliance), adopt the accepted behaviour in order to establish a relationship with others (i.e., concept of identification), perceive the induced behaviour as beneficial for them personally (i.e., concept of internalisation) (Kelman 1958).
   According to the theory on team effectiveness (Shortell et al. 2004) developing effective teams is suggested to be a crucial prerequisite for improved quality of care of patients.
   Effective leadership is thought to be the core concept of leadership theories. Øvretveit (2004), for example, has seen a number of factors promoting effective leadership and thus improved practice in healthcare including healthcare staff's involvement in decision making and modelling of values, proving flexible strategies and resources, developing a vision and offering training opportunities to healthcare staff.
2. Fuller et al. (2012): Theoretical Domains Framework (TDF) and MRC Framework for complex interventions
   The TDF (Cane et al. 2012) is a synthesis of 33 behavioural theories in the form of 14 domains (i.e., knowledge, skills, social/professional role and identity, beliefs about capabilities, optimism, beliefs about consequences, reinforcement, intentions, goals, memory and decision processes, environment context and resources, social influences, emotion, behavioural

regulation) that offer a theoretical lens through which to view the aspects that influence behaviour (e.g. cognitive, emotional) (Atkins et al. 2017).

The updated version of the MRC Framework for complex interventions (Craig et al. 2008) provides a guide for healthcare-related intervention development and places emphasis on the early piloting phases and development work (figure 6).

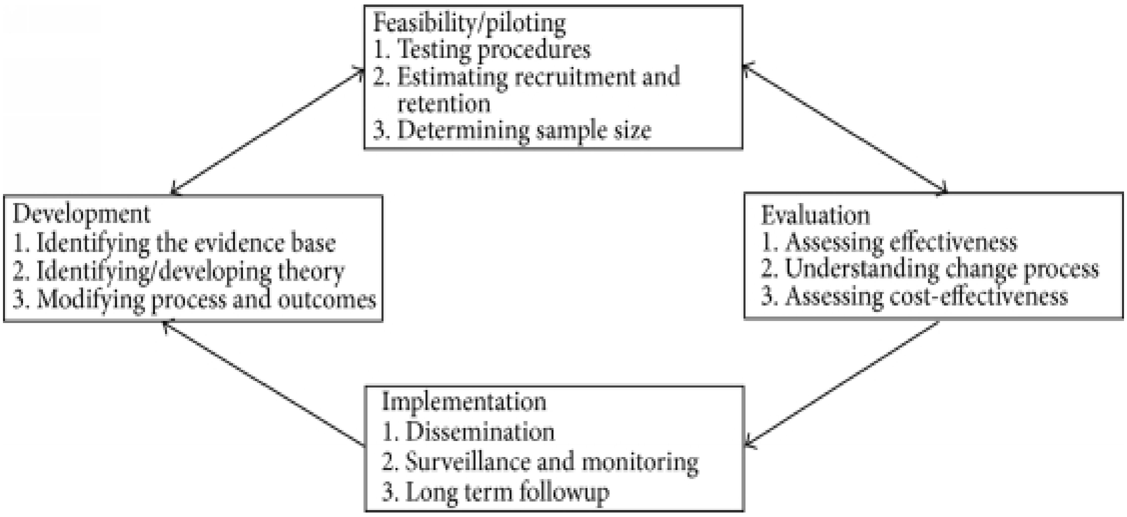


Figure 6. Representation of the key aspects of the MRC Framework for complex interventions (source: Craig et al. 2008).

3. Harne-Britner et al. (2011): change theory combined with aspects of behavioural, social science, and organisational theory

   Change theory refers to the thanstheoretical model proposed by Prochaska and Diclemente (1983) and refers to the different stages of readiness of the individual in changing behaviour (figure 7).

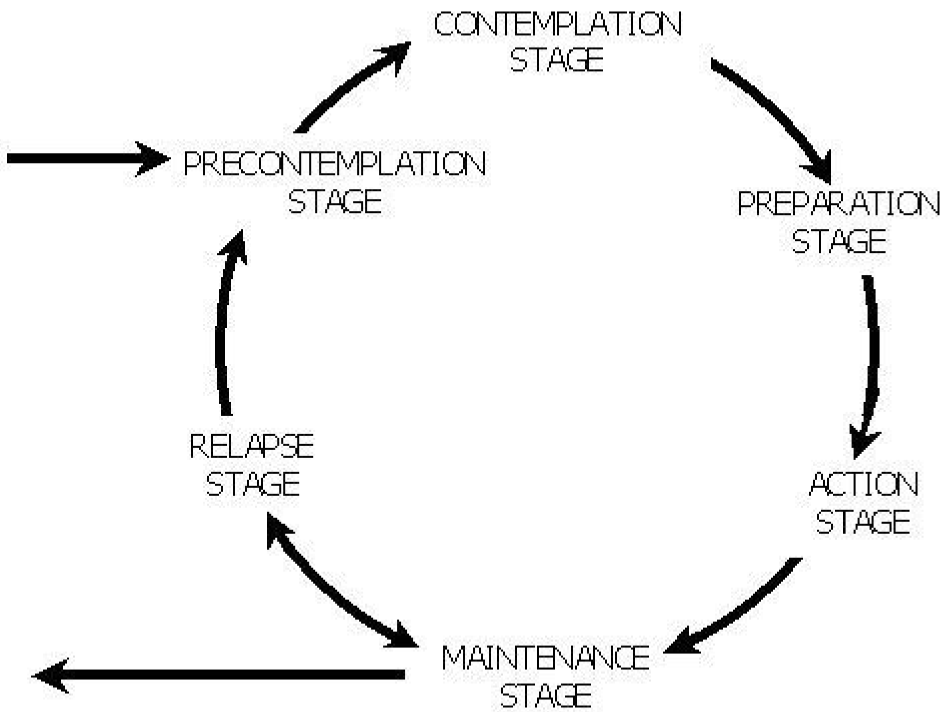


Figure 7. The Transtheoretical model (Prochaska and DiClemente, 1983) - Stages of readiness towards behaviour change

4. Curry and Cole (2001): ecological behaviour change model, health belief model, and social cognitive theory
   According to the ecological behaviour change model (McLeroy et al. 1988) individual, organisational, community and policy-related factors as well as their interactions should be scrutinised to positively influence behaviour change (figure 8).

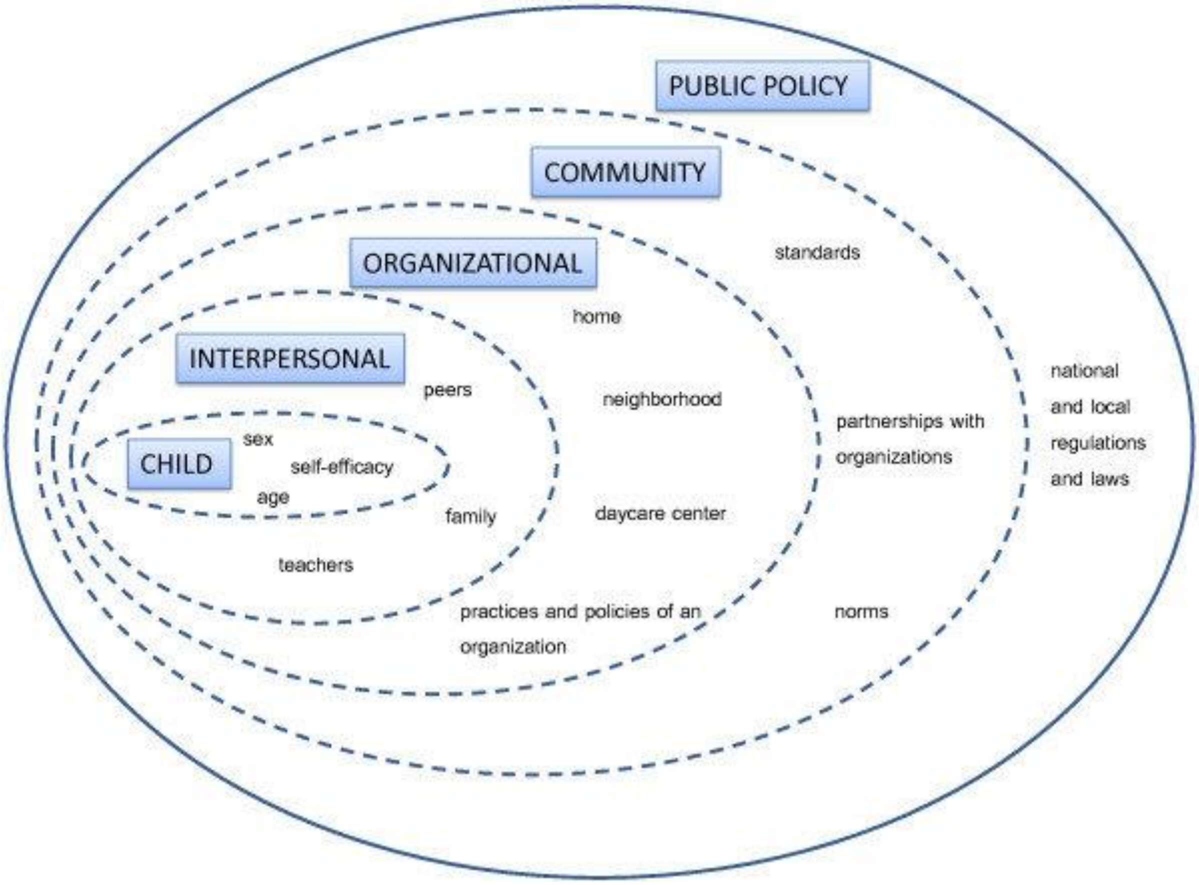


Figure 8. Representation of the ecological behaviour change model (Adopted from McLeroy et al. 1988)

The health belief model (Rosenstock 1990) postulates that an individual's engagement with health-promoting behaviour can directly be predicted by the perceived benefits and barriers and the perceived threat of a particular condition or situation, her/his level of confidence in successfully performing a certain behaviour as well as the available cues to action which can be either external (e.g. doctor's advice) or internal (e.g. physical pain) (figure 9).

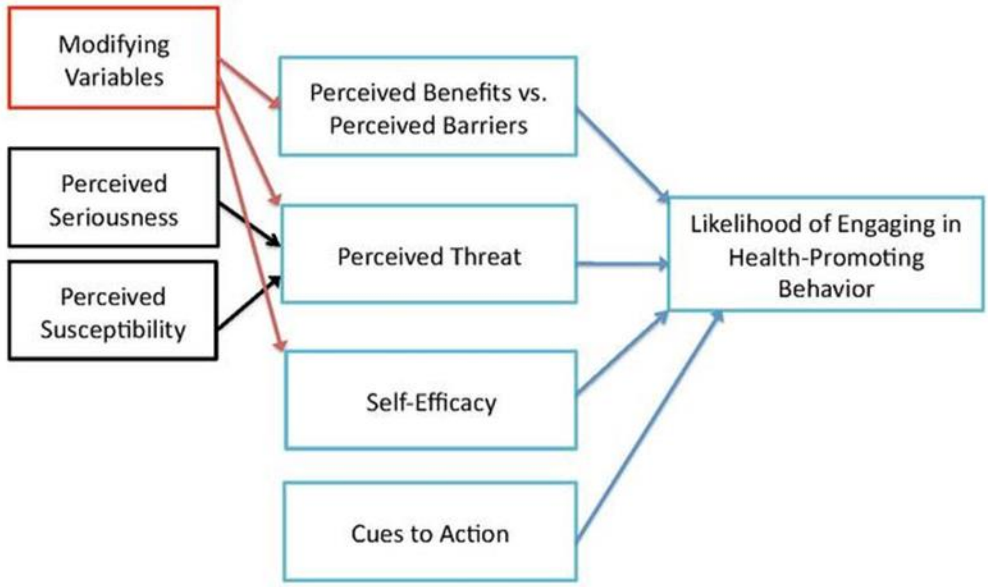


Figure 9. Schematic representation of the health belief model (Rosenstock, 1990)

Social cognitive theory (Bandura 1986) which is an extension of social learning theory (mentioned previously) describes a dynamic and reciprocal process where behaviour is influenced by, and can in turn influence personal e.g. self efficacy) and environmental (e.g. social influences) factors (figure 10) (Phipps et al. 2013).

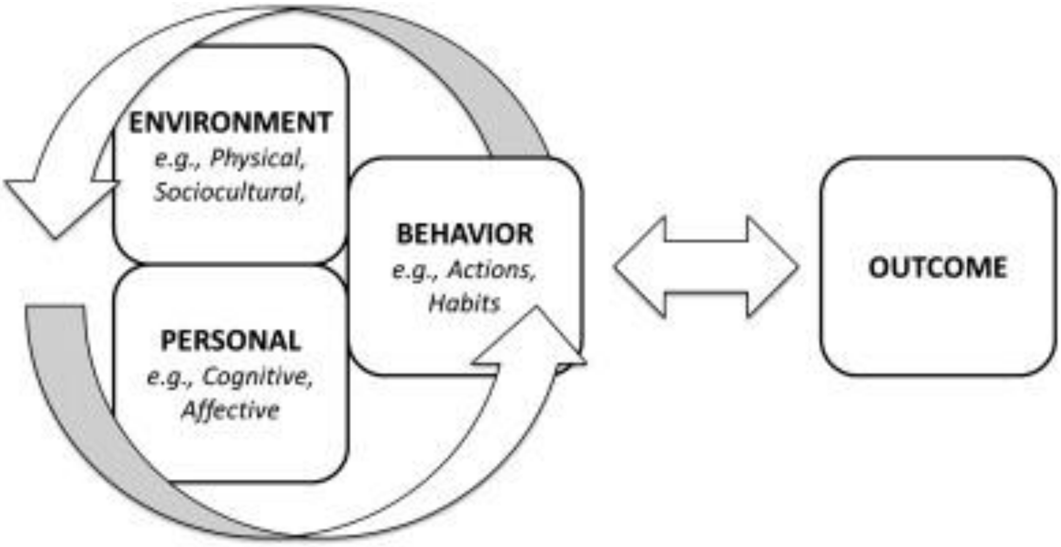


Figure 10. Social cognitive theory as a dynamic and reciprocal process (Adopted from Phipps et al. 2013)

5. Pontivivo et al. (2012): 5 moments for HH, thranstheoretical, model (stages of change), and Pathman model
   The Pathman model also known as awareness-to-adherence model (Pathman et al. 1996) describes the steps towards clinical guideline compliance. Initially targeted at physicians, the model postulates that physicians comply with practice guidelines through becoming aware of, and agreeing with them, and then deciding to adopt them in their daily practice and finally comply at appropriate times (Pathman et al. 1996).
6. Sharma et al. (2015): PRECEDE-PROCEED model, transtheoretical model stages of change), frontline ownership, and social marketing
   The concept of patient safety is at the core of frontline ownership (Zimmerman et al. 2013) suggesting that healthcare staff follow (by agreeing and taking ownership) or buy-in (by being imposed) leaders' ideas or plans. Social marketing is linked to the '4Ps' (product, price, place, promotion) approach and can contribute to the development and promotion of customer-focussed products and services (Vinnikainen 2017)

Appendix 5 – Studies excluded in IR2

Authors, year	Reasons for exclusion
Borges et al. 2012	Multi-component and visuals over 50% though not 100%. However, no evaluation data that is attributed specifically or clearly to visual components only. The outcome measures are HH rates and infection rates.
Boudjema et al. 2014	This is a pilot calibration and validation study which could be used for "future intervention studies". So not an intervention study as such.
Boudjema et al. 2017	Single component study - video with feedback but intervening to understand behaviour rather than explicitly evaluating impact of the video and feedback itself on awareness, knowledge or behaviour (no evidence presented).
Chami et al. 2012	Multi-component intervention; visuals (posters) seem less than 50% of this and there is no specific evaluation data re their effectiveness.
Conway et al. 2014	Multi-component intervention. The reports have visual components (tables and histograms/graphs) beyond written text and also managers could use a website to customise other feedback info. Unclear if the visuals more than 50% of intervention but no specific evaluation data on the visual elements anyway.
Dogra et al. 2015	Multi-component and visuals over 50% but no specific evaluation of their effectiveness.
El-Kafrawy et al. 2013	It turns out this study was with visitors only although they propose a study with staff re rings.
Forrester et al. 2010	Multi-component with posters the main element i.e. over 50% but no evaluation of the posters.
Gautschi et al. 2017	It turns out video was just a means of recording in this study (and wasn't feedback), whereas audio was the intervention.
Grice et al. 2008	Study of poster and alcohol gel placement. Arguable whether posters 50% but there is no specific data collected re the posters' specific effectiveness (it is to do with the combination with alcohol gel and overall placement, and also makes assumptions about effect).
Haidegger et al. 2011	Calibration/validation study rather than an intervention one.
Hargrove 2014	A control design comparing badge invitation visual (and also verbal invitation) with group who just get video. Posters are also involved. It seems to use quantification to look at impact but also factors (therefore gets into black box a bit). Focus on patient intentions but it is a staff.
Ho et al. 2012	No full text-authors contacted
Kampf et al. 2013	Visuals probably less than 50% of intervention and anyway no specific data collected re their effect. Exclude
Kamsu-Foguem et al. 2014	Interesting detailed examination of visual reasoning involved in temporal graphs but does not actually evaluate it with any staff – their case study seems conceptual. Exclude.
Konicki 2014	Full thesis not available-author contacted
Konicki et al. 2016	It turns out that the video was 6 mins and the in-person simulation teaching was 15 mins – no data relating specifically to the visuals.
Lehotsky et al. 2016	The interventions here are a video, an in-person demo, then use of u/v light to assess HH technique. Therefore multi-component with visuals more than 50%. However, we only get data on the parts people missed/did well on one occasion (so no data on effectiveness in terms of impact of tool or change) and not on participants evaluations of the visual aspects.

Lucas et al. 2017	Arguable if visuals 50% here but in any case they are not specifically addressed in data collection (which is all about compliance with HH).
Mertz et al. 2010	It turns out the posters are clearly less than 50% of this multi-component intervention and no specific data collected in relation to them.
Mukerji et al. 2013	Two phase intervention where e-learning module was major component. Very difficult to know how much this was visual and/or text based although seems more like quizzes. Can't assume a module is necessary a visualisation intervention just because electronic. Second phase intervention had posters and screensavers but also other aspects. So unclear if visuals over 50% net. However only distal measures collected with no visuals-specific feedback.
Neo et al. 2017	This turns out to be a validation study with observations used to cross-check. Spatial syntax does not appear to be being used as an intervention as such – rather it is a cross sectional design to understand what is happening normally in different settings. As such, exclude.
Owens et al. 2015	Multi-component intervention where posters the only visual element – hard to tell if 50% or not but in any case no specific data collected in relation to the visuals. Distal measures only. Exclude.
Porzig-Drummond et al. 2009	Series of experiments with visuals designed to evoke various levels of disgust. Regression/stats enabled consideration of each so in effect single components within one overall study. Data collected both proximally and distally linked to the visuals. Interesting study. Some debriefing apparently. However the participants seem not to be HCWs or healthcare students.
Rashidi et al. 2016	Otherwise valid study but never clear in the article if staff were involved (presumably some were but not explicit).
Salama et al. 2013	Multi-component intervention including leaflets and posters but several other non-visual elements. Visuals don't seem 50% and anyway no direct evidence related to visuals was collected.
Sanoh et al. 2010	Multi-component intervention of which DVD is only one visual. Not 50%.
Snider 2012	It seems the visual part (fluro marking gel) was used solely to monitor and the intervention was a new disinfectant.
Szilagyi et al. 2013	Five stage intervention with visual elements in two of these. No specific data collected re visuals.
Tai 2011	Poster display seems to have been a relatively minor part of this multi-component intervention. Visuals under 50%.
Villanueva et al. 2016	No full text-authors contacted
Wu et al. 2011	Intervention is online module using graphics, text and videos but little detail of these and hard to assess if 50%. Evaluation outcomes very distal and no evidence of data relating specifically to visuals. Exclude.
Xiao et al. 2007	No full text-authors contacted
Zhang et al 2010	Multi-component educational programme which had a 10 minute video. Not 50%.
Zomer et al. 2015	RCT of multi-component intervention including posters and stickers as one part of a four part intervention. Not 50% and lack of evidence collected re effectiveness of visuals.
Zomer et al. 2016	Essentially the same study as above but looking at other distal outcomes. Intervention below 50%.

Appendix 6 – QI-MQCS tool

Quality Improvement Minimum Quality Criteria Set (QI-MQCS) – Version 1.0

ID: ________ Author, year: ____________________________________ Reviewer: _________

Intervention: _______________________________________ Outcome: ________________________________

Domain	Minimum standard	Score
1. Organizational Motivation: Organizational problem, reason, or motivation for the intervention ♦ Consider quality of care problems; organizational problems; regulations, legal constraints, and external financial incentives at the target organization; or organizational motivation.	Names or describes at least one motivation for the organization's participation in the intervention	Not met Met
2. Intervention Rationale: Rationale linking the intervention to its expected effects ♦ Consider citations of theories, logic models, or existing empirical evidence that links the intervention to its expected effects.	Names or describes a rationale linking at least one central intervention component to intended effects	Not met Met
3. Intervention Description: Change in organizational or provider behaviour ♦ Consider the presented details that describe the change in the delivery of care, provider behaviour, or structure of the organization needed to replicate the evaluated intervention including the involved key personnel.	Describes at least one specific change in detail including the personnel executing the intervention	Not met Met
4. Organizational Characteristics: Demographics or basic characteristics of the organization ♦ Consider environment (e.g., urban/rural, academic/non-academic), type of care (e.g., primary care), size of the organization, patient mix, staff mix, or reimbursement type.	Reports at least two organizational characteristics	Not met Met
5. Implementation: Temporary activities used to introduce potentially enduring changes ♦ Consider types of staff involved, activities or methods used such as pilot testing or Plan-Do-Study-Act (PDSA) cycles, staff education, and involvement of stakeholders in introducing the intervention.	Names at least one approach used to introduce the intervention	Not met Met
6. Study Design: Study design and comparator ♦ Consider the type of evaluation (e.g., post-only, pre-post, time series, parallel control group, randomized groups; same participants assessed multiple times or different samples) / how the authors evaluated whether the intervention worked	Names the study design	Not met Met
7. Comparator: Information about comparator care processes ♦ Consider details about the control group or the status quo without the intervention (even if there was no formal control group / data), e.g., the existing standard of care / routine care / before the intervention was introduced, or care processes used in the control group.	Describes at least one key care process	Not met Met
8. Data Source: Data source and outcome definition ♦ Consider the data sources (e.g., routine hospital data, data collected by the study investigator), the data collection method (e.g., survey, interview, objective/subjective measurement) and the outcome of interest is defined (e.g., definition of a reportable patient fall).	Describes the data source and defines the outcome of interest	Not met Met

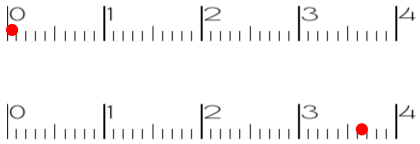
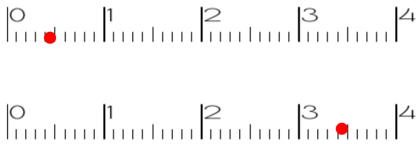
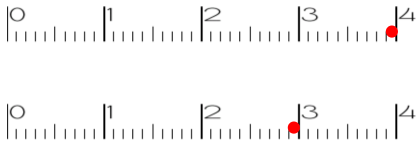
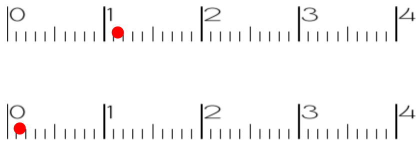
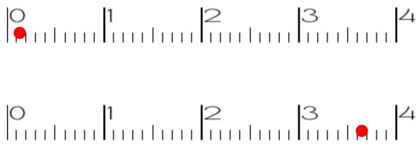
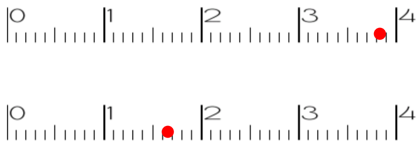
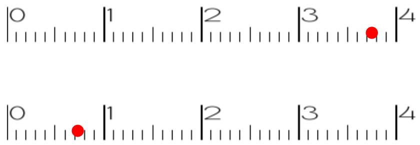
<u>9. Timing:</u> Timing of intervention and evaluation ♦ Consider the clarity of the timeline of the intervention, e.g., when introduced, when fully implemented, when evaluated relative to the intervention implementation status, and a clear indication of whether baseline data (defined as before the intervention was introduced) was present.	Describes the timing of the intervention and evaluation to determine the presence of baseline data and the follow-up period after all intervention components were fully implemented	Not met Met
<u>10. Adherence / Fidelity:</u> Adherence to the intervention ♦ Consider reporting of compliance with the intervention for the duration of the study, fidelity data on intervention use, or described mechanisms that ensures compliance (e.g., provider reminder integrated in electronic health record that cannot be skipped).	Reports fidelity information for at least one intervention component, or describes evidence of adherence or a mechanism ensuring compliance to the intervention	Not met Met
<u>11. Health Outcomes:</u> Patient health-related outcomes ♦ Consider patient and non-professional care-giver health-related outcomes (including e.g., quality of life), but exclude satisfaction, provider-behaviour (e.g., number of diagnostic tests ordered, knowledge) and process improvements.	Reports data on at least one health-related outcome	Not met Met
<u>12. Organizational Readiness:</u> Barriers and facilitators to readiness ♦ Consider reported QI resources and culture (e.g., existing QI committee, leadership commitment, prior QI experience, staff attitudes, and education and decision support resources) and results of barriers and facilitator assessments.	Reports at least one organizational-level barrier or facilitator	Not met Met
<u>13. Penetration / Reach:</u> Penetration / reach of the intervention ♦ Consider the number of units or sites participating in the intervention compared to the available / eligible units (e.g., the number of participating sites without knowing how many sites were initially approached / were eligible is not sufficient).	Describes the proportion of all eligible units who actually participated	Not met Met
<u>14. Sustainability:</u> Sustainability of the intervention ♦ Consider discussions of sustainability, reference to organizational resources (e.g., costs and necessary commitments) and policy changes needed to sustain the intervention after withdrawal of study personnel and research resources, evidence of enduring changes (e.g. automated electronic reminders), or an extended duration of the intervention period as evidence of sustainability.	Describes the sustainability or the potential for sustainability	Not met Met
<u>15. Spread:</u> Ability to be spread or replicated ♦ Consider evidence of spread or failure to spread and large rollouts; available resources such as a toolkits, how-to manuals, protocols, or booklets that describe the intervention in detail and could facilitate spread and replication; or discussions of spread potential.	Describes the potential for spread, existing tools for spread, or spread attempts / large-scale rollout	Not met Met
<u>16. Limitations:</u> Interpretation of the evaluation ♦ Consider whether the interpretation of the reported findings takes the study design (e.g., the lack of comparator) or other evaluation limitations into account; refers to the presented data (not future research / developments or intervention limitations)	Reports at least one limitation of the design / evaluation	Not met Met

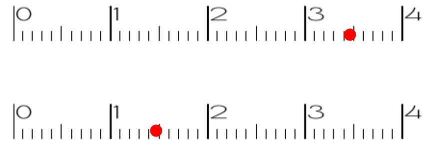
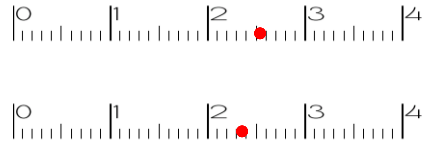
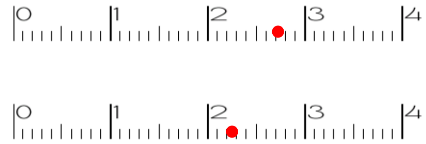
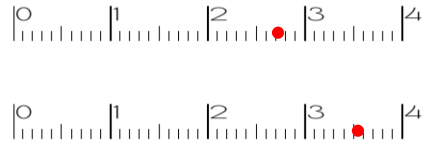
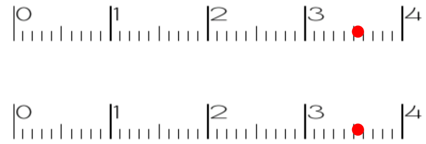
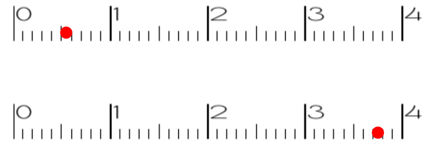
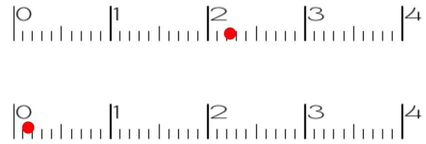
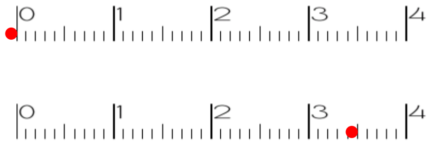
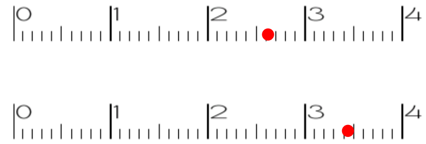
Appendix 7 – CASP qualitative Checklist

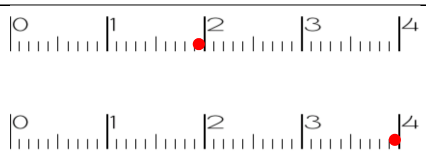
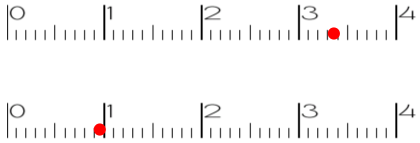
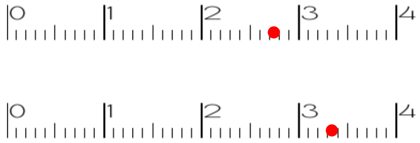
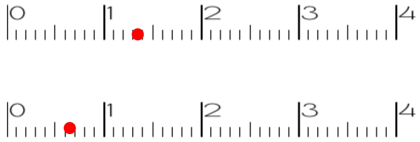
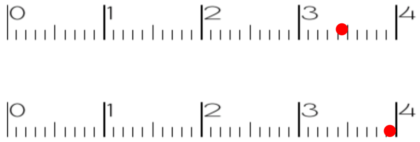
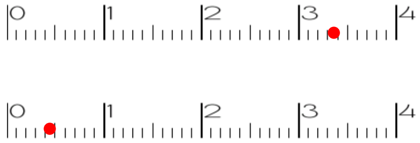
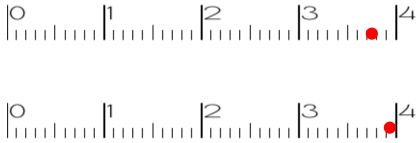
CASP qualitative Checklist	**Yes**	**Can't tell**	**No**
Section A: Are the results of the trial valid? 1. Was there a clear statement of the aims of the research? 2. Is a qualitative methodology appropriate? 3. Was the research design appropriate to address the aims of the research? 4. Was the recruitment strategy appropriate to the aims of the research? 5. Was the data collected in a way that addressed the research issue? 6. Has the relationship between researcher and participants been adequately considered?			
Section B: What are the results? 7. Have ethical issues been taken into consideration? 8. Was the data analysis sufficiently rigorous? 9. Is there a clear statement of findings?			
Section C: Will the results help locally? 10. How valuable is the research?			

The CASP qualitative Checklist as presented above is a summarized form of its online version: https://casp-uk.net/wp-content/uploads/2018/03/CASP-Qualitative-Checklist-2018_fillable_form.pdf

Appendix 8 – '4-point ruler' used for mapping IR2 studies

ID	**Article**	**Quadrant**	**Axis**	**Main graph:** **Nature of intervention** (X: orientation, Y: engagement)	**Reviewers' classification on predominant change approach** (based on Chin and Benne, 1985) noting that there is often a mix, and some may not fit any exactly
23	Yoon et al. 2016	Top left	X Y		E-R
17	Stewardson et al. 2014	Top left	X Y		E-R
6	Kukanich et al. 2013	Top right	X Y		E-R with some Norm-Re-ed
20	Weggelaar-Jansen et al. 2016	Bottom left	X Y		Mix of Power-coercive and a bit of Norm-re-ed in terms of the peer pressure propositions
8	Macdonald et al. 2017	Top right	X Y		E-R
11	Nevo et al. 2010	Bottom right	X Y		Power co-ercisive
14	Radhakrishna et al. 2015	Bottom right	X Y		Mix of all 3: Power co-ercive/nudge to some extent, but Norm-re-ed and E-R a bit once in staff member's consciousness

5	Diegel-Vacek et al. 2016	Bottom right	X Y		Power co-ercive/nudge
15	Sanchez-Carrillo et al. 2016	Top right	X Y		Strong example of Norm-re-ed
16	Sharma et al. 2015	Top right	X Y		Norm-re-ed with some E-R
9	Mackert et al. 2014	Top right	X Y		Norm-re-ed with some E-R
18	Storey et al. 2014	Top right	X Y		Mix of all 3: Mostly Norm-re-ed and E-R but elements of Power-Co-ercion or nudge in terms of the badge system
2	Beam et al. 2014	Top left	X Y		E-R with some Norm-Re-ed
3	Birnbach et al. 2016	Bottom right	X Y		Mostly E-R with a bit of Norm-Re-ed and Power-Co-ercive in the signs. To work as E-R signs would have to impact at conscious level but may be liminal in this context - ? mismatch between intervention and context?
7	Lehotsky et al. 2015	Top left	X Y		E-R
1	Assanasen et al. 2008	Top right	X Y		Norm-re-ed with some E-R

4	Caniza et al. 2007	Top right	X Y		E-R with some Norm-Re-ed
10	Morse et al. 2009	Bottom rght	X Y		Strongly E-R with a bit of Norm-Re-ed
12	Pedersen et al. 2017	Top right	X Y		Strongly Power-co-ercive although masquerades a bit as Norm-Re-ed.
13	Pope et al. 2014	Bottom left	X Y		E-R with some Norm-Re-ed
21	Wiles et al. 2015	Top right	X Y		Norm-re-ed with some E-R
19	Wearn et al. 2015	Bottom right	X Y		E-R with a bit of Norm-Re-ed. To work as E-R signs would have to impact at conscious level but may be liminal in this context - ? mismatch between intervention and context?
22	Wyer et al. 2017	Top right	X Y		Strongly Norm-Re-ed but goes beyond this to an empowerment type ideology because it seems concerned with understanding human factors beyond simplistic focus on compliance.

Appendix 9 – Invitation e-mail sent to recruit Delphi key experts

Dear (Ms, Mr, Dr, Prof *name of expert*),

My name is Kostas Tsattalios and I am a PhD candidate at Robert Gordon University, Aberdeen, UK. I am writing to invite you to participate in a Delphi study which forms a significant part of my research.

The aim of the study is to recognise experts' opinions and move towards consensual agreement on how to best develop behaviour change interventions in the field of healthcare-associated infections (HAIs). You have been invited to participate in this study due to your knowledge and expertise in healthcare/behaviour change-related research involving either theory, visualisation or both.

HAIs remain a high threat for patients and healthcare staff resulting in alarming morbidity and mortality rates as well as increasing costs for the healthcare system. Within educational and practice based interventions to help address HAIs, theory and visualisations are often used as contributory or central components. However, these have not yet been the subject of systematic and comprehensive study. Based on this notion and taking stock of the current researcher's systematic exploration of the field, it is envisaged that your opinions (i) will serve as a catalyst for the development of behaviour change interventions primarily in the HAIs field, and (ii) will also offer potentially useful knowledge for intervention development in other aspects of healthcare.

You are invited to participate in 3 rounds of questioning and surveys, which explore what may be prioritised within such an intervention focussing primarily on the role of theory and visualisation delivery modes as well as the selection of behaviour change techniques and how to increase the effectiveness of such interventions.

Each round is envisaged to take up to 20 minutes to complete. You will be asked to provide your responses electronically using a survey link that will be sent to you well in advance. You will be kindly asked to respond to each round within two weeks, and there will be a 4-week interval between each round.

Please do not hesitate to contact me or my principal supervisor if you wish to ask any question:

Mr Kostas Tsattalios

PhD candidate
School of Nursing and Midwifery,
Robert Gordon University, Garthdee,
Aberdeen, AB10 7QG
Tel: +44(0)7761889930
E-mail: k.tsattalios@rgu.ac.uk

Principal supervisor: Dr Colin Macduff

Visiting Reader
School of Nursing and Midwifery,
Robert Gordon University
Garthdee, Aberdeen, AB10 7QG
E-mail: c.macduff@rgu.ac.uk

We believe that your knowledge and expertise would be very beneficial for developing more effective behaviour change interventions that optimally utilise theory and visualisations.

Should you wish to contribute in the advancement of this field please respond by e-mail as soon as possible and I will forward the instructions for the first Delphi round including a participant information sheet and consent form.

Many thanks in advance for your time and consideration.

Yours sincerely,

Mr Kostas Tsattalios

Appendix 10 – Participant information sheet for Delphi study

DELPHI STUDY INFORMATION SHEET

Towards consensus in the development of behaviour change interventions that best combine theory and visualisations in the healthcare-associated infections field: a Delphi study

Dear (Ms, Mr, Dr, Prof *name of expert*),

As part of my PhD research at Robert Gordon University, I am conducting a Delphi study that seeks to develop a set of guidelines to inform behaviour change interventions combining theory and visualisations in the field of healthcare-associated infections (HAIs). Before completing the online questionnaire, it is important for you to understand why the research is being conducted and what your participation will involve. Please, take time to read this information carefully. Do ask us if there is anything that is not clear or if you would like more information.

What is a Delphi Study?
The Delphi study refers to a forecasting technique used to obtain the collective views of informed individuals, also known as *experts,* about issues where there is little or no agreement and where expert opinion is important (Thangaratinam & Redman 2005). The Delphi study is chosen in order to enable consultation from a geographically diverse group of experts and to gain consensus while allowing them to consider and respond to each other's views (Linstone and Turoff 2002). Also, the Delphi study facilitates anonymity among its experts which can allow for unashamed freedom of speech and more accurate opinion giving (Strauss and Zeigler 1975).

What is the rationale for, and purpose of the Delphi study?
The proposed Delphi study is part of my PhD research. It is based on the premise that the use of theory and visualisations when optimally combined have the potential to positively impact on healthcare staff's behaviours regarding infection prevention and control (IPC) (e.g. hand washing, adherence to hygiene regulations). This assertion is rooted in pertinent healthcare research that embraces the development of theory-based and visualisation-centred interventions such as in obesity (e.g. Taylor et al 2013), smoking cessation (e.g. Whittaker et al 2011), asthma and physical activity (e.g. Murray et al 2016), sexual health behaviour (e.g. Garcia-Retamero & Cokely 2011) and promotion of

self-management (e.g. Williams et al 2012). However, these two concepts (i.e., theory and visualisation) have not yet been the subject of systematic and comprehensive study in the field of IPC and HAIs. For this reason and prior to the inception of this Delphi study, I undertook two separate integrative reviews (IR). One looked at theory-based interventions (IR1: https://www.crd.york.ac.uk/prospero/display_record.asp?ID=CRD42016035934) and the other looked at visualisation-centred interventions (IR2: https://www.crd.york.ac.uk/prospero/display_record.asp?ID=CRD42017048142) aiding healthcare staff to prevent and control healthcare-associated infections. Overall, the two IRs: did not determine one definitive theory (IR1) or visualisation (IR2) as being dominant, provided low or no justification for the selection of theory and visualisation (in IR1 and IR2 respectively), identified a variety of designs the majority of which were not strong in conventional terms (e.g. before and after designs) and showed no long-term effectiveness in the developed interventions.

Taking stock of the major findings of the two IRs, the main purpose of the Delphi study is to harness expert knowledge to identify types of theory and visualisation that can optimally be combined and best inform the development of pertinent interventions in the field of HAIs and IPC. In view of the need to control the consequences of suboptimal IPC behaviours and persistent HAIs rates, your contribution could help to shed light and advance the field and further promote the use of evidence based and creative visualisation options to support behaviour change.

Why have I been invited to take part?
As an established expert with relevant knowledge and experience in healthcare, visualisation and/or behaviour change-related research your views will be helpful for moving towards achieving consensus guidance in this field. Your invitation is, therefore, based on the identification of your research outputs (i.e., published research papers from 2000 onwards and conference proceedings from relevant conferences between 2015-2017), or your contribution in specific academic networks (i.e., Healthcare Associated Infection Visualisation and Ideation Research Network; HAIVAIRN) or recommendations from other academics.

What will I be asked to do if I take part?
The Delphi study is comprised of 3 rounds: one questionnaire round (round 1) and two survey rounds (rounds 2 & 3). In round 1, you will be asked to provide your opinion in 6 questions related to the development of behaviour change interventions in the field of HAIs with a primary focus on the concepts of theory, visualisations, and their optimal combination. You will, also, have the opportunity to propose further suggestions as to how to improve the development of such interventions. To participate in round 1 you will have to click on the web link that I will send to you and to follow the instructions. It is envisaged that it will not take more than 20 minutes to complete round 1.

Responses from round 1 will be integrated with findings from the integrative reviews to construct the statements that will be the focus of round 2. The round 2 survey format will invite you to indicate your level of agreement for each of these statements and provide a brief explanation in a free text response. Finally, round 3 will include only these statements for which consensus was not reached, receiving a reminder of your previous rating and all participants' average rating for each of these statements. You will be given the option to retain or adjust your previous rating providing again a brief justification if possible. As per round 1, separate web links will direct you to round 2 and 3 surveys respectively which are not expected to take more than 20 minutes to complete. Please, note there are no right or wrong responses to the questions. This Delphi study is seeking your expert opinion.

In order to allow timely preparation, analysis and conclusion of the Delphi study a response time within two weeks for completion of each round is respectfully requested. There will, also, be an approximate 4-week interval between the commencement of each round. Finally, reminders may be sent to you close to the response deadlines for each round if required.

What are the benefits?
The recommendations that the research aims to develop are geared towards researchers and are anticipated to enable use of optimal combination of theory and visualisation for the development (and related evaluation) of HAI-related interventions. It is therefore envisaged that this research will serve as a catalyst for the development of behaviour change interventions utilising theory and visualisations primarily in the HAI field, but will also offer useful knowledge for intervention development in other fields of healthcare research.

What are the risks?
No particular risks or complications have been identified in relation to participation in the study. Below, you can find the contact details of my Principal Supervisor shall you wish to obtain more information about the study or to raise any concerns or worries you may have.

What if I decide I no longer wish to participate in this study?
Your participation is totally voluntary and it is up to you to decide whether or not to participate. If you decide to take part you will be initially asked to complete and return a consent form. If you initially agree to participate, but then decide to withdraw then this is fine. In this case, please tell me (Kostas Tsattalios, School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG, tel: 07761889930, e-mail: k.tsattalios@rgu.ac.uk) so you will be removed from the e-mail list.

What happens to the information?
You will not be asked to provide any personal information and your questionnaire and survey responses will be collated anonymously using an identifying number known only to myself, my supervisory team and yourself. All responses you will provide in the study will be treated with strict confidentiality as per Robert Gordon University policies and your identity will not be divulged at any phase of the study. Direct quotes you will provide may be used in later rounds of the Delphi or

disseminated as part of the final thesis or subsequent publications and conference presentations but they will not be traceable back to you. If any of these quotes include an indication of your identity then these quotes will not be used.

Data protection
The Delphi study will be conducted electronically with your questionnaire and survey responses be collected via a quality-assured Robert Gordon University in-home online survey tool. The survey tool will utilise an encrypted internet server. According to Data Protection Act (1998), data will be stored in a secure protected location and in a password protected computer within premises of Robert Gordon University. Data will be kept for a period of 10 years after which it will be destroyed. Shall you wish, you have the right to access submitted information on request.

What happens at the end of the study?
Each participant will be sent a brief summary of the findings achieved by the end of round 3. Further analysis will be ongoing and each Delphi contributor will be sent the weblink to the final thesis on RGU Open Air once available. It is, also, anticipated that the findings of the Delphi study will disseminated as a standalone publication in a peer-reviewed journal and presented at relevant conferences as appropriate.

Who is organising and funding the research?
The current Delphi study is part of my PhD project, which is generously funded by Robert Gordon University.

Research ethics
The proposed research abides by the ethical requirements of Robert Gordon University and it has been reviewed and approved by the School of Nursing and Midwifery Ethics Review Panel (SERP) (SERP reference: 17-23). A copy of the submitted ethics application and decision letter can be provided to you on request. If you have any further questions about this study, please do not hesitate to contact me: Mr Kostas Tsattalios, School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG (Tel: +44(0)7761889930, E-mail: k.tsattalios@rgu.ac.uk)

What if I have concerns about this research?
If you are worried about this research, or if you are concerned about how it is being conducted, you can contact my principal supervisor Dr Colin Macduff, Visiting Reader, School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG (E-mail: c.macduff@rgu.ac.uk)

Thank you for considering taking part in this research.

Indicative bibliography

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Appendix 11 – Round 1 online questionnaire of the Delphi study

ROBERT GORDON UNIVERSITY ABERDEEN

Towards consensus in the development of behaviour change interventions that best combine theory and visualisations in the healthcare-associated infections field: a Delphi study

Dear Participant

Thank you for accepting my invitation to participate in this Delphi study. The study is exploring how to best develop behaviour change interventions in the fie of healthcare-associated infections (HAIs) focussing on the use of theory and visualisation.
The following points may be useful as a reminder of the study's context and rationale before you move on to completing the questions:

- The findings of this study will be of constructive benefit and guidance to other researchers aiming **to develop more effective behaviour change interventions** targeted at supporting healthcare staff with HAIs, infection prevention and control procedures, adherence to hygiene regulations etc.
- **A wide view of theory** has been taken in this study **including frameworks and models.** In the previously conducted integrative review of theory-based interventions (IR1) in the field of HAIs (see participant information sheet), a number of theories were identified for the development of interventions including: PRECEDE model, Roger's diffusion of innovations model, health belief model, sociothechnical systems framework, transtheoretical model, PDS cycles, social cognitive theory. However, other theories/models may be very relevant.
- Visualisation in this study is regarded as **any external** (e.g. poster) **or internal** (e.g. mental images) **means for visually representing HAIs-related concepts.** In my preceding integrative review of visualisation-centred interventions (IR2) in the field of HAIs (see participant information sheet), various visualisation types were the **central, substantive component/s** of the interventions. These included: colour posters, use of staff's video recordings, signs/visual cues, videotapes and flipcharts, flashing lights, remote video auditing, video reflexive ethnography, electronic educational-based devices providing personalised visual feedback (e.g. performance on hand hygiene technique). Some initial mappings of these are available in Section 5 of the Findings within a recent report about the HAIVAIRN network, downloadable at: HAIVAIRN: Report on the HAIVAIRN
- From these integrative reviews it appears that **theory and visualisation have not been yet extensively coupled nor has their selection been adequatel justified** whenever the two have been combined. Thus eliciting experts' creative thinking about potentially successful theory-visualisation dyads would helpfully inform the evidence base in this field.
- Behaviour change techniques (BCTs) can be seen as the **'active ingredients'** of interventions – those process aspects that bring about behaviour change outcomes.

Your Personal ID REQUIRED

[ ]

Please indicate your primary discipline REQUIRED

- ○ Education/Curriculum Development
- ○ Engineering
- ○ Art
- ○ Design
- ○ Health Sciences
- ○ Health Humanities
- ○ Medicine
- ○ Microbiology
- ○ Nursing
- ○ Psychology
- ○ Sociology
- ○ Other

Please specify

[ ]

Please indicate your expertise (tick all that apply) REQUIRED

- ☐ Some expertise in theory
- ☐ Some expertise in visualisation
- ☐ Some expertise in behaviour change
- ☐ Some expertise in infection prevention and control
- ☐ Other expertise

Please specify

[ ]

1. In your view, what theory(ies), framework(s) or model(s) can best inform interventions to help prevent and control healthcare-associated infections (HAIs)? Please give any explanations and examples of interventions and intended outcomes.

2. In your view, what types of visualisation can best inform interventions to help prevent and control HAIs? Please give any explanations and exa
of interventions and intended outcomes.

3. In your view, which of the above theories and visualisations could best be combined for such interventions? Please give any explanations and examples of interventions and intended outcomes.

4. With reference to the 'Behaviour change techniques taxonomy' v1 below (Michie et al., 2013), type in the space below any behaviour change techniques (BCTs) that can best facilitate the delivery of such interventions? Can you, also, explain why?

Behaviour change techniques taxonomy v1 (Michie et al., 2013) (PDF 43KB)

5. How can the long-term effectiveness of such interventions be sustained? Please, give any examples and/or explanation.

6. What other recommendations would you suggest for the development of interventions combining theory and visualisation? Can you, also, explain why?

Thank you for completing the questionnaire!
An e-mail will be sent to you in approximately 4 weeks from the commencement of this first round, providing instructions and the survey link of the second round.
Should you have any question do not hesitate to contact me:
Tel: +44(0)7761889930, E-mail: k.tsattalios@rgu.ac.uk

Submit Form Reset

Appendix 12 – Consent form for Delphi key experts

DELPHI STUDY CONSENT FORM

Towards consensus in the development of behaviour change interventions that best combine theory and visualisations in the healthcare-associated infections field: a Delphi study

Lead researcher: Kostas Tsattalios
Participant ID:

Please initial box

1. I confirm that I have read and understood the participant information sheet explaining the above research project and I have had the opportunity to ask questions about the project 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. In addition, should I not wish to answer any particular question or questions I am free to decline.
3. I am fully aware that data collected will be stored securely, safely in premises of Robert Gordon University and in accordance with Data Protection Act (1998) with only myself and supervisors having access to them when necessary. Data will be retained for 10 years and will be destroyed when it is no longer needed for the project.
4. I give permission for my anonymised quotes to be used during the Delphi rounds and to be accessed by the research team. I am aware that my name will not be linked with the research material I and will not be identifiable during the Delphi survey.
5. I agree for the data collected from me to be used in an anonymised and unidentifiable form in future research and/or disseminated (e.g. conference presentation, journal publication)
6. I agree to take part in this study.

Name of Participant	**Date**	**Signature**
Name of Lead Researcher	**Date**	**Signature**

Completion: Please return scanned or electronically completed forms via email to: k.tsattalios@rgu.ac.uk. Alternatively, please return hard copies by post to the following address: Kostas Tsattalios, School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG

Further information: This research has been reviewed and approved by the School of Nursing and Midwifery Ethics Review Panel (SERP) at Robert Gordon University (SERP reference: 17-23). If you have any further questions about this study, please do not hesitate to contact me:

Kostas Tsattalios
School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG
Tel: 07761889930
E-mail: k.tsattalios@rgu.ac.uk

What if I have concerns about this research?

If you are worried about this research, or if you are concerned about how it is being conducted, you can contact my principal supervisor:

Dr Colin Macduff, Visiting Reader
School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG
E-mail: c.macduff@rgu.ac.uk

Copies: Please retain a copy of the completed consent from for your personal records. An additional copy will be held in a University secure location for the duration of the research study.

Appendix 13 – Round 2 questionnaire of the Delphi study

Towards consensus in the development of behaviour change interventions that best combine theory and visualisations in the healthcare-associated infections field: a Delphi study

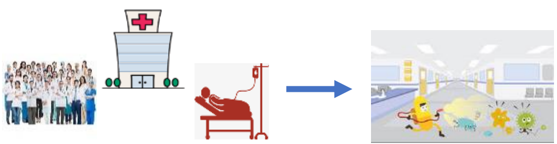
Dear Participant,

Thank you for your valuable contribution in Round 1 of this Delphi study. This yielded very rich and useful data which has informed Round 2 in general and/or specific ways.

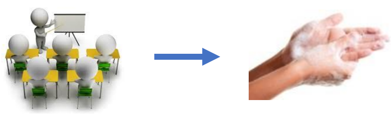
The structure of this survey round has been influenced by feedback and comments you gave in round 1 in order to provide more focus on the context and behaviours under exploration within this study. Broadly the literature reviews and Round 1 responses indicate two predominant approaches: (i) systems-wide, multi-modal interventions which seek to decrease HAI rates, and (ii) focal interventions targeted at increasing HH compliance. Therefore, these have been used here as the basis of two scenarios that you are asked to read and consider. **Then please choose only one so that you anchor your responses to the statements on this particular scenario**.

It is important to highlight that the concept of 'behaviour change' as I presented it in Round 1 was not tied with a strict definition leaving it more open to your interpretation. In fact, within the context of infection prevention and control, behaviour change can be seen as a blend of related concepts moving across a continuum, for example: from raising awareness, increasing intentions to change, actual behaviour change, to decreasing infection rates and sustaining behaviour change.

Scenario 1
This scenario is targeted at developing systems-wide behaviour change interventions involving the whole healthcare institution, in this case a typical general hospital. Interventions in this scenario are targeted across the whole professional population of the institution aiming to decrease infection rates.



Scenario 2
This scenario is targeted at developing focal behaviour change interventions involving individual department(s) within the healthcare institution and/or small teams of healthcare staff. The department(s) and/or teams in this scenario would be part of a typical general hospital and interventions are aiming specifically to increase HH compliance among healthcare workers.



Please, indicate your preferred scenario by entering 1 or 2 in box:

It is expected to take no more than 25 minutes to complete this survey.

Abbreviations:

- HAIs: Healthcare-associated infections
- HCWs: Healthcare workers
- IPC: Infection prevention and control

PART A: Development of interventions Based on the scenario you chose (either scenario 1: systems-wide interventions aiming to decrease infection rates <u>OR</u> scenario 2: focal interventions aiming to increase HH compliance) read the following statements and rate them from 1 ('strongly disagree') to 5 ('strongly agree'). **What is useful to consider when developing interventions?** It is very useful to consider:		**Level of agreement** (respond by scaling each statement on degree of agreement from 1: 'strongly disagree' to 5: 'strongly agree' – click on box)				
		1 **Strongly disagree**	**2** **Disagree**	**3** **No opinion**	**4** **Agree**	**5** **Strongly agree**
1	Making interventions engaging, meaningful and pertinent.	☐	☐	☐	☐	☐
2	Conducting a meta-analysis of approaches to behaviour change across a number of contexts relevant to public health and not just HAIs.	☐	☐	☐	☐	☐
3	Service user perspectives and opinions when planning and implementing interventions as these are crucial to successful implementation	☐	☐	☐	☐	☐
4	The barriers to changing the behaviour of HCWs.	☐	☐	☐	☐	☐
5	Understanding of the people practicing the behaviour as well as the setting in which they practice the behaviour.	☐	☐	☐	☐	☐
6	Understanding what psychosocial and cultural factors affect behaviours.	☐	☐	☐	☐	☐
7	Ensuring human factors thinking is embedded in IPC interventions so that visualisation and cues to action become hard wired into IPC.	☐	☐	☐	☐	☐
8	The human hand and its complex role as a key part of communication and physical tasks across quickly changing environments and contexts of busy healthcare.	☐	☐	☐	☐	☐
9	Understanding the persuasive role of language in reducing infection.	☐	☐	☐	☐	☐
10	How multimodal strategies underpinned by multiple theories make sense in a practical implementation-focused way.	☐	☐	☐	☐	☐

Do you want to make any comments for particular statements or Part A in general?

PART B: Theories/Frameworks/Models

In this part, theories, models and frameworks from your responses are presented in three categories informed by Nilsen's (2015) classification. Based on the scenario you chose (either scenario 1: systems-wide interventions aiming to decrease infection rates OR scenario 2: focal interventions aiming to increase HH compliance) read the following statements and choose your most preferred 'Top 2' for each of the three categories (leave blank if you do not wish to indicate any preference).

What theories/frameworks/models are most useful for your chosen scenario?

Category 1: Describing and/or guiding the process of translating research into practice
It is very useful to consider:

1	Guiding IPC practice and facilitate decision making in determining the best practice as proposed by the Iowa Model of Evidence-Based Practice to promote Quality Care.	
2	Implementation theories which offer a stepwise approach (e.g. Grol and Wensing's model) and take the user through a series of rational and deliberate steps in order to accomplish practice improvement.	
3	Naturalistic decision-making models, such as fast and frugal models which may help the development of interventions that support and exploit naturalistic decision-making processes rather than impeding them.	
4	Co-design and co-development for developing interventions which have a hope of succeeding in IPC.	
5	Quality improvement approaches (e.g. Plan-Do-Study-Act cycles).	
6	The 'stages of change' people are at considering the different readiness levels they experience as in the case of the Trans-Theoretical Model of Change.	
7	Illustrating how knowledge transfers into practice by attending to the phases of awareness, agreement, adoption and adherence as Pathman's model suggests.	
8	Connecting people's behaviours with their emotions to help them see, feel then change as in the case of Kotter's eight-step change model.	

Category 2: Understanding and/or explaining what influences implementation outcomes
It is very useful to consider:

11	Systematically assessing multilevel implementation contexts to explore factors that can determine intervention implementation and effectiveness by using dedicated frameworks as in the case of the Consolidated Framework for Implementation Research.	
12	Theoretical Domains Framework which summarises data from several theories and proposes constructs that could be used to understand and inform interventions in healthcare, namely the implementation of evidence-based guidelines.	
13	Social marketing: a behaviour-change framework that has received growing support as a model for use in relation to infection prevention and control.	
14	4. Comprehensive Unit-based Safety Program (CUSP) framework to make healthcare safer by improving intra-team's co-operation.	
15	Healthcare factors systems models, as in the case of Systems Engineering Initiative for Patient Safety model.	

16	Theories that explain differences between doctors' and nurses' IPC practices (e.g. Bourdieu's theory of practice).	
17	Identifying intervention functions and policy categories considering what is understood about the targeted behaviour using approaches as in the case of the Behaviour Change Wheel.	
18	Social Cognitive Theory (outcome expectation, self-efficacy, barriers and facilitators) to understand the causal factors of the behaviour.	
19	Psychological decision-making models, as in the case of Theory of Planned Behaviour.	
20	Social science theories, as in the case of Roger's Diffusion of Innovation theory, to help understand how to adapt interventions to a specific individual or group.	
21	Psychological models that attempt to explain and predict health behaviour (e.g. Health Belief Model).	
22	BASNEF (the Behaviour, Attitude, Subjective Norms, and Enabling Factors) model to study behaviours, change them and to define the factors effective on individuals' decision making.	
23	Leventhal's common-sense model of health beliefs and behaviours model which considers not only human behaviour but also emotions and the context of behaviour.	
24	Affect Theory and the role of affects towards learning and change.	
25	Theories that facilitate learning as in the case of Kolb's experiential learning theory where the learner grasps information and transforms it so that it is meaningful to the individual.	
26	Theories targeting healthcare worker safety using reflective practice (e.g. Schön's theory) and verbal protocol analysis (e.g. Simon's theory) to evaluate clinical decision making.	
27	COM-B model: capability, opportunity, motivation for behaviour change.	
28	How clinicians normalise work as in the case of Normalization Process Theory that gives a better understanding of the context in which interventions need to be applied.	

Category 3: Evaluating implementation
It is very useful to consider:

19	Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) framework for program design which addresses both environmental factors and individual factors, such as knowledge, attitudes, and beliefs.	
20	The Medical Research Council (MRC) framework for developing and evaluating complex interventions.	

Do you want to make any comments for particular statements or Part B in general?

PART C: Visualisation

Based on the scenario you chose (either scenario 1: systems-wide interventions aiming to decrease infection rates OR scenario 2: focal interventions aiming to increase HH compliance) read the following statements and rate them from 1 ('strongly disagree') to 5 ('strongly agree').

What visualisations are most useful for your chosen scenario?

Level of agreement (respond by scaling each statement on degree of agreement from 1: 'strongly disagree' to 5: 'strongly agree' – click on box)

General statements about purpose, principles and/or context of visualisations
It is very useful to consider:

		1 Strongly disagree	2 Disagree	3 No opinion	4 Agree	5 Strongly agree
1	Visualisations that help one understand the complexities of a system.	☐	☐	☐	☐	☐
2	Visualisations that demonstrate transmission and pathogen reservoirs	☐	☐	☐	☐	☐
3	The shape of objects when developing interventions.	☐	☐	☐	☐	☐
4	Concrete imagery and language for learning and altering behaviours.	☐	☐	☐	☐	☐

Statements about specific visualisation forms and content
It is very useful to consider:

		1	2	3	4	5
5	Smart phone applications for educational/induction and/or reminder purposes.	☐	☐	☐	☐	☐
6	Colourful posters for conveying information and raising awareness.	☐	☐	☐	☐	☐
7	Short videos of staff and carers modelling the appropriate behaviours.	☐	☐	☐	☐	☐
8	Visual reminders for correct hand washing/rubbing.	☐	☐	☐	☐	☐
9	Simulation in the lab to allow the learner to apply their IPC-related skills using biosphere (fluoresces under ultra-violet light) to visually depict the spread.	☐	☐	☐	☐	☐
10	Visual/ video mapping that succinctly represents the pathways to infection within hospital sites.	☐	☐	☐	☐	☐
11	Video Reflexive Ethnography to show people what they are doing as others see them, and reflect on their unconscious or habituated actions.	☐	☐	☐	☐	☐
12	Dynamic animations, and hypermedia learning environments for education and instruction purposes.	☐	☐	☐	☐	☐
13	Fluorescent dyes to show HCWs about the good performance of the HH technique to improve the performance of the gesture - as HCWs can see what parts of the hands were not adequately cleaned.	☐	☐	☐	☐	☐
14	New technologies that provide direct and objective visual feedback on hand rubbing technique (e.g. Hand-in-Scan and SureWash devices).	☐	☐	☐	☐	☐

15	HCWs video recordings (e.g. use of cameras mounted in their heads) followed by analysis of their gestures to study the hand-surface or hand-patient touches in order to map these interactions.	☐	☐	☐	☐	☐
16	3D-technology/virtual reality where HCWs can actually see their hands contaminated during healthcare when performing simulation-based training.	☐	☐	☐	☐	☐
17	Internet-based social media (e.g. Twitter, LinkedIn, IPC blogs).	☐	☐	☐	☐	☐
18	Automatic sink lights as a prompt for clinician HH.	☐	☐	☐	☐	☐
19	Training-, and induction-based tablet applications using interactive visuals related to infection prevention and control and healthcare-associated infections.	☐	☐	☐	☐	☐
20	Screen savers with gain-framed messages to influence HCWs' HH behaviour.	☐	☐	☐	☐	☐
21	Flashing lights on alcohol-based hand-rubs as a prompt to HH.	☐	☐	☐	☐	☐
22	Warning signs prompting HCWs to wash their hands.	☐	☐	☐	☐	☐
23	Infographics to convey HAIs-related information.	☐	☐	☐	☐	☐
24	Visualisation of the bugs (e.g. by doing cultures of HCWs' hand prints)	☐	☐	☐	☐	☐

Do you want to make any comments for particular statements or Part C in general?

PART D: Long term effectiveness and sustainability Based on the scenario you chose (either scenario 1: systems-wide interventions aiming to decrease infection rates OR scenario 2: focal interventions aiming to increase HH compliance) read the following statements and rate them from 1 ('strongly disagree') to 5 ('strongly agree'). **How can such interventions be implemented effectively and sustained?** ***What behaviour change techniques are useful to inform behaviour change interventions?*** It is very useful to consider:		**Level of agreement** (respond by scaling each statement on degree of agreement from 1: 'strongly disagree' to 5: 'strongly agree' – click on box)				
		1 **Strongly disagree**	**2** **Disagree**	**3** **No opinion**	**4** **Agree**	**5** **Strongly agree**
1	Instruction on how to perform the behaviour	☐	☐	☐	☐	☐
2	Feedback on outcomes of behaviour	☐	☐	☐	☐	☐
3	Feedback on behaviour	☐	☐	☐	☐	☐
4	Goal setting (behaviour)	☐	☐	☐	☐	☐
5	Goal setting (outcome)	☐	☐	☐	☐	☐
6	Restructuring the physical environment	☐	☐	☐	☐	☐
7	Action planning	☐	☐	☐	☐	☐
8	Information about health consequences	☐	☐	☐	☐	☐
9	Social comparison	☐	☐	☐	☐	☐
10	Prompts/cues	☐	☐	☐	☐	☐
11	Habit formation	☐	☐	☐	☐	☐
12	Identification of self as role model	☐	☐	☐	☐	☐
13	Behavioural practice/rehearsal	☐	☐	☐	☐	☐
14	Material incentive (behaviour)	☐	☐	☐	☐	☐
15	Social reward	☐	☐	☐	☐	☐
How can the long-term effectiveness of such interventions be sustained? It is very useful to consider:						
16	More involvement and understanding on the part of the administration.	☐	☐	☐	☐	☐

17	Regular feedback about infection rates and behaviour coupled with salient people.	☐	☐	☐	☐	☐
18	Periodic competition among HCWs.	☐	☐	☐	☐	☐
19	Establishing some form of outstanding events (e.g. world HH day).	☐	☐	☐	☐	☐
20	Providing technical solutions and automatization.	☐	☐	☐	☐	☐
21	Making it easy to do the behaviours.	☐	☐	☐	☐	☐
22	Adopting recommendations in training and becoming a norm in clinic.	☐	☐	☐	☐	☐
23	Making structural changes in the environment.	☐	☐	☐	☐	☐
24	Attaching an emotional component in such interventions.	☐	☐	☐	☐	☐
25	Engaging HCWs in building a culture of safety.	☐	☐	☐	☐	☐
26	Establishing a healthy work environment from a managerial perspective to an intervention being sustained.	☐	☐	☐	☐	☐
27	Making the intervention easy to be incorporated into everyday practice.	☐	☐	☐	☐	☐
28	Frequent re-evaluation of interventions for salience and accuracy.	☐	☐	☐	☐	☐
29	Investment with a sustainable plan of continuous education, continuous iterative improvement of tools and interventions supported by feedback and robust evidence.	☐	☐	☐	☐	☐
30	All HCWs to take IPC improvement strategies as they own responsibility and not only the IPC group.	☐	☐	☐	☐	☐
31	Creation of regional networks.	☐	☐	☐	☐	☐
32	Defining clear objectives, clear plan of monitoring and feedback, surveillance and clear empowerment of the IPC group) and very continuous training and a defined programme for new HCWs in the institution.	☐	☐	☐	☐	☐
33	Habit formation for behavioural maintenance.	☐	☐	☐	☐	☐
34	Elements of shocking (like the tumorous lung pictures on tobacco packets).	☐	☐	☐	☐	☐

Do you want to make any comments for particular statements or Part D in general?

Thank you for completing the survey!

Please, send the completed survey back to me by e-mail to: k.tsattalios@rgu.ac.uk

An e-mail will be sent to you in approximately 4 weeks from the commencement of this second round, providing instructions and the survey link of the third and final round.

Should you have any question do not hesitate to contact me:
Tel: +44 (0) 7761889930, e-mail: k.tsattalios@rgu.ac.uk

Reference
Nilsen, P. (2015). Making sense of implementation theories, models and frameworks. *Implementation Science*, *10*(1), 53.

Do you wish to make any comments for this survey overall?

Appendix 14 – Example of round 3 questionnaire

Towards consensus in the development of behaviour change interventions that best combine theory and visualisations in the healthcare-associated infections field: a Delphi study

Dear______,

Thank you once again for your valuable contribution in Rounds 1 and 2!

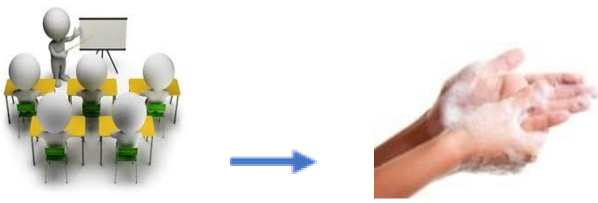
The current and final survey round is structured in the same way as in Round 2 (i.e. Parts A, B, C and D) including, though, only those statements that did not reach consensus.

In keeping with Delphi method, for each of these statements you will be reminded of your initial rating along with the distribution of all participants' ratings (for Parts A, C and D) and you will be given the chance to give another rating or retain your initial one.

In Part B, the same statements for which you were asked to indicate your familiarity and indicate your 'top 2' will be presented to you again in descending order (highest to lowest scores) based on the cumulative 'order preference' scores for each statement and you will be reminded of your initial 'top 2' selection with the option to alter or retain it.

Also, do keep in mind that the scenario you indicated in Round 2 as your preferred one is **'Scenario 2'**:

This scenario is targeted at developing focal behaviour change interventions involving individual department(s) within the healthcare institution and/or small teams of healthcare staff. The department(s) and/or teams in this scenario would be part of a typical general hospital and interventions are aiming specifically to increase HH compliance among healthcare workers.



The current survey round is expected to require no more than 20 minutes to complete.

Abbreviations:

- HAIs: Healthcare-associated infections
- HCWs: Healthcare workers
- IPC: Infection prevention and control

PART A: Development of interventions Considering scenario 2 (i.e., focal approaches to intervention development aiming to decrease infection rates), you are presented with those statements that did not reach consensus in Round 2 and you are asked to re-rate them if you wish or retain your initial rating taking into account all participants' ratings. **What is useful to consider when developing interventions for your chosen scenario?** It is very useful to consider:		**Your rating in Round 2**	**Distribution of responses by participants who chose scenario 2** (*N*=9 in total) 1 Strongly disagree	2 Disagree	3 No opinion	4 Agree	5 Strongly agree	**Your Round 3 rating** (please write in words)
9	Understanding the persuasive role of language in reducing infection.		*N*=0	*N*=1	*N*=2	*N*=3	*N*=3	
10	How multimodal strategies underpinned by multiple theories make sense in a practical implementation-focused way.		*N*=0	*N*=1	*N*=2	*N*=3	*N*=3	

If you wish, please make any comments for particular statements or Part A in general:

PART B: Theories/Frameworks/Models

In Round 2 you were asked to indicate your familiarity with statements related to theories/frameworks/models and indicate your 'top 2' preference. Each of these 2 statements received a score according to the preference order, i.e. 'statement 1'= 2 points, and 'statement 2'=1 point. Accordingly, a cumulative 'order preference' score* has been calculated for those statements indicated in the 'top 2' of all participants in scenario 1 and are presented below. Along with the cumulative 'order preference' score, you are reminded of your initial 'top 2' and are given the option to alter or retain your initial selection.

*Note that the higher this score is, the more likely is for this statement to have been ranked highly across the board. Similarly, the lower this score is, the more likely is for this statement to have been ranked low across the board.

What theories/frameworks/models are most useful for your chosen scenario?

Your 'top 2' in Round 2	***Category 1:*** *Describing and/or guiding the process of translating research into practice* It is very useful to consider:	**Cumulative order preference score**	**Your 'top 2' in Round 3 (**indicate a new 'top 2' or leave blank if you wish to retain your initial 'top 2')
	Co-design and co-development for developing interventions which have a hope of succeeding in IPC.	8	
	Quality improvement approaches (e.g. Plan-Do-Study-Act cycles).	6	
	Implementation theories which offer a stepwise approach (e.g. Grol and Wensing's model) and take the user through a series of rational and deliberate steps in order to accomplish practice improvement.	3	
	Naturalistic decision-making models, such as fast and frugal models which may help the development of interventions that support and exploit naturalistic decision-making processes rather than impeding them.	2	
	The 'stages of change' people are at considering the different readiness levels they experience as in the case of the Trans-Theoretical Model of Change.	2	
	Connecting people's behaviours with their emotions to help them see, feel then change as in the case of Kotter's eight-step change model.	2	
	Guiding IPC practice and facilitate decision making in determining the best practice as proposed by the Iowa Model of Evidence-Based Practice to promote Quality Care.	1	
	Illustrating how knowledge transfers into practice by attending to the phases of awareness, agreement, adoption and adherence as Pathman's model suggests.	0	

Your 'top 2' in Round 2	***Category 2**: Understanding and/or explaining what influences implementation outcomes* It is very useful to consider:	**Cumulative order preference score**	**Your 'top 2' in Round 3 (**indicate a new 'top 2' or leave blank if you wish to retain your initial 'top 2')
	Theories that facilitate learning as in the case of Kolb's experimental learning theory where the learner grasps information and transforms it so that it is meaningful to the individual.	5	
	Theoretical Domains Framework which summarises data from several theories and proposes constructs that could be used to understand and inform interventions in healthcare, namely the implementation of evidence-based guidelines.	4	
	Psychological models that attempt to explain and predict health behaviour (e.g. Health Belief Model).	3	
	Systematically assessing multilevel implementation contexts to explore factors that can determine intervention implementation and effectiveness by using dedicated frameworks as in the case of the Consolidated Framework for Implementation Research.	2	
	Healthcare factors systems models, as in the case of Systems Engineering Initiative for Patient Safety model.	2	
	Theories that explain differences between doctors' and nurses' IPC practices (e.g. Bourdieu's theory of practice).	2	
	Theories targeting healthcare worker safety using reflective practice (e.g. Schön's theory) and verbal protocol analysis (e.g. Simon's theory) to evaluate clinical decision making.	2	
	COM-B model: capability, opportunity, motivation for behaviour change.	2	
	Identifying intervention functions and policy categories considering what is understood about the targeted behaviour using approaches as in the case of the Behaviour Change Wheel.	1	
	Social Cognitive Theory (outcome expectation, self-efficacy, barriers and facilitators) to understand the causal factors of the behaviour.	1	
	Psychological decision-making models, as in the case of Theory of Planned Behaviour.	1	
	Affect Theory and the role of affects towards learning and change.	1	
	Social marketing: a behaviour-change framework that has received growing support as a model for use in relation to infection prevention and control.	0	
	Comprehensive Unit-based Safety Program (CUSP) framework to make healthcare safer by improving intra-team's co-operation.	0	
	Social science theories, as in the case of Roger's Diffusion of Innovation theory, to help understand how to adapt interventions to a specific individual or group.	0	
	BASNEF (the Behaviour, Attitude, Subjective Norms, and Enabling Factors) model to study behaviours, change them and to define the factors effective on individuals' decision making.	0	
	Leventhal's common-sense model of health beliefs and behaviours model which considers not only human behaviour but also emotions and the context of behaviour.	0	
	How clinicians normalise work as in the case of Normalization Process Theory that gives a better understanding of the context in which interventions need to be applied.	0	
	Understanding the cause of challenges in a system by understanding the system through the lens of a Macro-ergonomics approach (e.g. Socio-technical Systems theory).	0	

Your 'top 2' in Round 2	***Category 3:** Evaluating implementation* It is very useful to consider:	**Cumulative order preference score**	**Your 'top 2' in Round 3 (**indicate a new 'top 2' or leave blank if you wish to retain your initial 'top 2')
	Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) framework for program design which addresses both environmental factors and individual factors, such as knowledge, attitudes, and beliefs.	6	
	The Medical Research Council (MRC) framework for developing and evaluating complex interventions.	3	

If you wish, please make any comments for particular statements or Part B in general:

PART C: Development of interventions

Considering scenario 2 (i.e., focal approaches to intervention development aiming to increase HH compliance), you are presented with those statements that did not reach consensus in Round 2 and you are asked to re-rate them if you wish or retain your initial rating taking into account all participants' ratings.

What visualisations are most useful for your chosen scenario?

General statements about purpose, principles and/or context of visualisations

	It is very useful to consider:	**Your rating in Round 2**	**Distribution of responses by participants who chose scenario 2** (*N*=9 in total) 1 Strongly disagree	2 Disagree	3 No opinion	4 Agree	5 Strongly agree	**Your Round 3 rating** (please write in words)
3	The shape of objects when developing interventions.		*N*=0	*N*=1	*N*=4	*N*=3	*N*=1	

Statements about specific visualisation forms and content		Distribution of responses by participants who chose scenario 2 (*N*=9 in total)						
It is very useful to consider:		**Your rating in Round 2**	1 Strongly disagree	2 Disagree	3 No opinion	4 Agree	5 Strongly agree	**Your Round 3 rating** (please write in words)
15	HCWs video recordings (e.g. use of cameras mounted on their heads) followed by analysis of their gestures to study the hand-surface or hand-patient touches in order to map these interactions.		*N*=1	*N*=2	*N*=1	*N*=2	*N*=3	
17	Internet-based social media (e.g. Twitter, LinkedIn, IPC blogs).		*N*=1	*N*=0	*N*=5	*N*=3	*N*=0	
18	Automatic sink lights as a prompt for clinician HH.		*N*=0	*N*=1	*N*=4	*N*=3	*N*=1	
20	Screen savers on computers with gain-framed messages to influence HCWs' HH behaviour.		*N*=0	*N*=2	*N*=4	*N*=2	*N*=1	
21	Flashing lights on alcohol-based hand-rubs as a prompt to HH.		*N*=0	*N*=1	*N*=7	*N*=1	*N*=0	
22	Warning signs prompting HCWs to wash their hands.		*N*=0	*N*=2	*N*=2	*N*=4	*N*=1	
23	Infographics to convey HAIs-related information.		*N*=0	*N*=0	*N*=4	*N*=4	*N*=1	

If you wish, please make any comments for particular statements or Part C in general:

PART D: Long term effectiveness and sustainability Considering scenario 2 (i.e., focal approaches to intervention development aiming to increase HH compliance), you are presented with those statements that did not reach consensus in Round 2 and you are asked to re-rate them if you wish or retain your initial rating taking into account all participants' ratings. **How can such interventions be implemented effectively and sustained for your chosen scenario?** ***What behaviour change techniques are useful to inform behaviour change interventions?*** It is very useful to consider:		**Your rating in Round 2**	**Distribution of responses by participants who chose scenario 2 (*N*=9 in total)** 1 Strongly disagree	2 Disagree	3 No opinion	4 Agree	5 Strongly agree	**Your Round 3 rating** (please write in words)
7	Action planning		*N*=0	*N*=2	*N*=2	*N*=4	*N*=1	
9	Social comparison		*N*=0	*N*=1	*N*=2	*N*=4	*N*=2	
14	Material incentive (behaviour)		*N*=0	*N*=1	*N*=3	*N*=4	*N*=1	

How can the long-term effectiveness of such interventions be sustained It is very useful to consider:		**Your rating in Round 2**	**Distribution of responses by participants who chose scenario 2** (*N*=9 in total) 1 Strongly disagree	2 Disagree	3 No opinion	4 Agree	5 Strongly agree	**Your Round 3 rating** (please write in words)
16	More involvement and understanding on the part of the administration.		*N*=0	*N*=1	*N*=2	*N*=3	*N*=3	
18	Periodic competition among HCWs.		*N*=0	*N*=2	*N*=3	*N*=3	*N*=1	
19	Establishing some form of outstanding events (e.g. world HH day).		*N*=0	*N*=1	*N*=2	*N*=3	*N*=3	
22	Adopting recommendations in training and becoming a norm in clinic.		*N*=0	*N*=1	*N*=2	*N*=4	*N*=2	
24	Attaching an emotional component in such interventions.		*N*=0	*N*=1	*N*=3	*N*=3	*N*=2	
31	Creation of regional networks.		*N*=0	*N*=1	*N*=3	*N*=4	*N*=1	
34	Elements of shocking (like the pictures of lung tumours on tobacco packets).		*N*=2	*N*=0	*N*=3	*N*=3	*N*=1	

If you wish, please make any comments for particular statements or Part D in general:

Thank you for taking the time to complete the survey and participate in this Delphi study! Your contribution is once again deeply appreciated.

Please, send the completed survey back to me by e-mail to: k.tsattalios@rgu.ac.uk .
Should you have any question do not hesitate to contact me:
Tel: +44 (0) 7761889930, e-mail: k.tsattalios@rgu.ac.uk

If you wish, please make any comments for this survey overall:

Appendix 15 – Delphi round 1 themes and sub-themes

Themes	**Sub-themes**
Theory	Theory examples Challenge in translating theory into practice Justification of theory selection Overwhelming amount of theories
Visualisation	Visualisation examples Visualise hand's impacts Concrete and clear visuals Infection pathways Raising awareness Lack of visualisation techniques
Combining theory and visualisation	Example of combinations Factors-depended combination of theory-visualisation Visualisation and behavioural determinants Rely on existing approaches Aiming for simplicity
Planning the development of interventions	Identifying behaviour barriers and facilitators Considering the setting, origin of outbreaks and type of HAIs Importance of interpersonal & organisational levels Importance of participatory design BCTs Cognitive psychology approach Adopting a stepwise approach Service user perspectives and opinions
Healthcare as a system	Understanding the system Efficiency in changing the system Complex role of HCWs hands System's complexities Hospital seen as a system by leadership The role of a well-designed system Facilitation of compliance by the system System change
Staff education	Protocols and smart phone apps Experiential learning Educating and preparing nursing students Challenges Direct demonstration and teaching Increasing awareness and CPD Use of gain-framed language in training Educational opportunities
Sustaining effectiveness	BCTs Involvement of staff and administration Building safety culture Frequent re-evaluation of interventions Expanding focus to the general public Use of guidelines Incorporating interventions into practice Contextualising and refreshing visualisations Creation of regional networks

Appendix 16A – Topic guide for focus groups with infection control teams

FOCUS GROUP DISCUSSION TOPIC GUIDE

(Infection control team)

TITLE OF PROJECT: Facilitating Adherence to Hygiene Policies in Infection Prevention and Control: Considering the Role of Theory and Visualisations in Behaviour Change Interventions

Before starting I need to make sure that participants:

- (Re)read the participant information sheet and retained a copy.
- Signed the consent form and retained a copy.
- Had the chance to ask any questions related to the focus group study.
- Are reminded that the discussion will be audio recorded (I need to ensure that the audio recorder is in place and ready to start recording).

NHS setting:	**Department/ward**:	**Date:** 24/08/2018
[Name of NHS Health Board]	Infection Control team	**Start time:**

START OF FOCUS GROUP

INTRODUCTION-WELCOME

Good morning/afternoon everyone. I would like to thank you for taking the time to participate in this focus group discussion. My name is Kostas and I am a PhD student at Robert Gordon University exploring the role of theory and visualisation approaches in behaviour change interventions in the field of infection prevention and control and healthcare-associated infections. I aim to compile a set of recommendations about how such interventions can best be informed by theory and visualisations, and how can they be more effective facilitating thus better healthcare staff's daily routine in hygiene practices. Towards this direction, your active involvement in education of colleagues, audit, surveillance, advice, outbreak management, research and information around infection prevention and control (amongst other things) are crucial for the development of these recommendations. Therefore, your opinions and thoughts based on your professional role within the infection control team will help me gain an in-depth understanding of the aforementioned issues (i.e., theory, visualisation etc.). Remember this is a discussion about your experiences and there are no right or wrong answers. Finally, I want to remind you our discussion will be audio-recorded, all information will be treated with confidentially and no names will be used in any subsequent dissemination of findings related to this study.

Do you want to ask any question? Are you ready to get started?

PART A		
1. <u>Factors influencing adherence to hygiene policies/recommendations</u> *Can I start by asking you some questions about IPC? I am interested in your day to day practices at work towards decreasing infection rates.*	**Possible probes**	**Comments/Notes**
What policies/recommendations guide healthcare staff's practice across the hospital?	*Can you provide specific examples?* - *Are they international, national or more local ones?* - *What does anyone else think?*	
Which is your 'top 2' of these factors, either inhibitors or enablers, that researchers should highly consider when developing interventions to support healthcare staff's daily practice?	- *Factors that inhibit/enable performance?* - *Can you give a practical example?* - *Could you provide with more details on that?* - *What does anyone else think?*	
What would you regard as an intervention is in the context of IPC?	- *Is an intervention different from normal practice and why?* - *Would you explain that further?* - *What does anyone else think?*	
What types of interventions are implemented in your hospital and how successful are these interventions at supporting healthcare staff?	- *Can you give an example?* - *What does anyone else think?*	
Which of the aforementioned factors do these interventions incorporate?	- *Could you provide with more details on that?* - *What does anyone else think?*	
2. <u>Visualisation approaches to intervention development</u> *Now I would like to talk about visualisation approaches to intervention development. By visualisation approach I mean any approach utilising visual aids to convey messages, stimulate*	**Possible probes**	**Comments/Notes**

attention and bring about positive behaviour change (in this case leading to less infections).		
What visualisation approaches have been implemented at your hospital in relation to IPC?	- *Could you provide with more details on that?* - *What does anyone else think?*	
To what extent do you think these visualisation approaches have been successful?	- *Can you explain why?* - *Can you give an example of how they have been successful to you personally but also to your team?* - *What does anyone else think?*	
What types of visualisations do you think could IPC control and towards less infection rates?	- *Would you explain that further?* - *Can you give a practical example?* - *How could these be part of related interventions?* - *What does anyone else think?*	
Thinking of the factors influencing adherence to hygiene policies, as you mentioned earlier, how could visualisation approaches contribute towards successful IPC and lower infection rates?	- *Can you describe a simple example?* - *Would you explain that further?* - *What does anyone else think?*	
3. Long-term effectiveness and sustainability of interventions *Now I would like to talk about how these interventions could be more effective leading to sustainable positive outcomes.*	**Possible probes**	**Comments/Notes**
In your opinion, how could these interventions increase their long-term effectiveness leading to sustainable positive outcomes for example lower infection rates?	- *Can you give an example?* - *Could you provide with more details on that?* - *What does anyone else think?*	

PART B		
4. <u>Considering experts' recommendations from the Delphi study</u> *Now I will briefly present to you some recommendations given to me primarily by academic experts in healthcare/behaviour change-related research involving either theory, visualisation or both.*	**Possible probes**	**Comments/Notes**
Firstly, I want to ask you about each of the elements of these recommendations. What is your understanding of, and experience with the following concepts: -Co-design -COM-B (Capability, Opportunity, Motivation-Behaviour) model -Visual/video mapping of infection pathways/pathogen transmission -Interventions based on feedback on behaviour and its outcomes -Restructuring the physical environment	- *Can you give an example?* - *Could you provide with more details on that?* - *What does anyone else think?*	
Experts' recommendations: Experts highly agreed that understanding the people practicing the behaviour as well as the setting in which they practice the behaviour is key. Towards this direction, it is essential that healthcare staff are actively involved in the development of IPC-related interventions, an approach termed as 'co-design'. Along with staff's involvement, the COM-B model can give a logical structure to designing an intervention. They, also, recommended using visual/video mapping of infection pathways/pathogen transmission and reservoir. They finally highly agreed that providing feedback on behaviour and its outcomes, restructuring the physical environment and making interventions easy to be incorporated into everyday practice are essential elements towards successful interventions. How do these recommendations sound to you? Are they in the right direction to facilitating healthcare staff's IPC-related practices?	- *Are these recommendations already in place?* - *Would this combination of recommendation be feasible and work towards less infection rates across the hospital?* - *What does anyone else think?*	
What, if any, suggestions you would like to make regarding the development of interventions combining theory (or theory-related aspects) and visualisations towards decreasing infections across the whole hospital?	- *Can you give an example?* - *Could you provide with more details on that?* - *What does anyone else think?*	

CONCLUSION

This is me finished me with the questioning. Is there anything else I did not ask and you would like to add? Thank you once again for your time and your valuable input.

Focus group discussion concluded at (specify end time):

CLOSE OF FOCUS GROUP DISCUSSION

Appendix 16B – Topic guide for focus groups with nurses from paediatric hospitals

FOCUS GROUP DISCUSSION TOPIC GUIDE

(Department/ward-based clinical nurses)

TITLE OF PROJECT: Facilitating Adherence to Hygiene Policies in Infection Prevention and Control: Considering the Role of Theory and Visualisations in Behaviour Change Interventions

Before starting I need to make sure that participants:

- (Re)read the participant information sheet and retained a copy.
- Signed the consent form and retained a copy.
- Had the chance to ask any questions related to the focus group study.
- Are reminded that the discussion will be audio recorded (I need to ensure that the audio recorder is in place and ready to start recording).

NHS setting:	**Department/ward**:	**Date:** **____/____/2018** **Start time:**

START OF FOCUS GROUP

INTRODUCTION-WELCOME

Good morning/afternoon everyone. I would like to thank you for taking the time to participate in this focus group discussion. My name is Kostas and I am a PhD student at Robert Gordon University exploring the role of theory and visualisation approaches in behaviour change interventions in the field of infection prevention and control and healthcare-associated infections. I aim to compile a set of recommendations about how such interventions can best be informed by theory and visualisations, and how can they be more effective facilitating thus better your daily routine towards hygiene practices. Therefore, your opinions and thoughts based on your daily clinical practice will help me gain an in-depth understanding of the aforementioned issues. Remember this is a discussion about your experiences and there are no right or wrong answers. Finally, I want to remind you our discussion will be audio-recorded, all information will be treated with confidentially and no names will be used in any subsequent dissemination of findings related to this study.

Do you want to ask any question? Are you ready to get started?

<table>
<tr><th colspan="3">PART A</th></tr>
<tr><td>1. <u>Factors influencing adherence to hygiene policies/recommendations</u>
Can I start by asking you some questions about your HH practices? I am interested in your day to day practices at work.</td><td>Possible probes</td><td>Comments/Notes</td></tr>
<tr><td>What policies/recommendations guide your practice?</td><td>- Can you provide specific examples?
- Are they international, national or more local ones?
- What does anyone else think?</td><td></td></tr>
<tr><td>Which is your ‘top 2’ of these factors, either inhibitors or enablers, that researchers should highly consider when developing interventions to support your daily practice re HH?</td><td>-Factors that inhibit/enable performance?
- Can you give a practical example?
- Could you provide with more details on that?
- What does anyone else think?</td><td></td></tr>
<tr><td>What do you think an intervention is in the context of IPC and HH?</td><td>- Is an intervention different from normal practice and why?
- Would you explain that further?
- What does anyone else think?</td><td></td></tr>
<tr><td>What types of interventions are implemented in your clinic/department and how successful are these interventions at supporting you?</td><td>- Can you give an example?
- What does anyone else think?</td><td></td></tr>
<tr><td>Which of the aforementioned factors do these interventions incorporate?</td><td>- Could you provide with more details on that?
- What does anyone else think?</td><td></td></tr>
<tr><td>2. <u>Visualisation approaches to intervention development</u>
Now I would like to talk about visualisation approaches to intervention development. By visualisation approach I mean any approach utilising visual aids to convey messages, stimulate attention and bring about positive behaviour change (in this case improve HH).</td><td>Possible probes</td><td>Comments/Notes</td></tr>
</table>

What visualisation approaches have been implemented at your clinical area in relation to infection prevention and control and HH?	- *Could you provide with more details on that?* - *What does anyone else think?*	
To what extent do you think these visualisation approaches have been successful?	- *Can you explain why?* - *Can you give an example of how they have been successful to you personally but also to your team?* - *What does anyone else think?*	
What types of visualisations do you think could support your daily practice in relation to infection control and HH?	- *Would you explain that further?* - *Can you give a practical example?* - *How could these be part of related interventions?* - *What does anyone else think?*	
Thinking of the factors influencing adherence to hygiene regulations, as you mentioned earlier, how could visualisation approaches contribute towards successful infection control and hygiene?	- *Can you describe a simple example?* - *Would you explain that further?* - *What does anyone else think?*	
3. <u>Long-term effectiveness and sustainability of interventions</u> *Now I would like to talk about how these interventions could be more effective leading to sustainable positive outcomes for example improved HH adherence.*	**Possible probes**	**Comments/Notes**
In your opinion, how could these interventions increase their long-term effectiveness leading to sustainable positive outcomes for example improved HH?	- *Can you give an example?* - *Could you provide with more details on that?* - *What does anyone else think?*	

PART B		
4. <u>Considering experts' recommendations from the Delphi study</u> *Now I will briefly present to you some recommendations given to me primarily by academic experts in healthcare/behaviour change-related research involving either theory, visualisation or both.*	**Possible probes**	**Comments/Notes**
Firstly, I want to ask you about each of the elements of these recommendations. What is your understanding of, and experience with the following concepts: -co-design? -holistic learning -lab simulation -Interventions based on habit formation and tailoring to practice	- *Can you give an example?* - *Could you provide with more details on that?* - *What does anyone else think?*	
Experts' recommendations: Experts highly agreed that making interventions engaging, meaningful and pertinent is key. Towards this direction, it is essential that healthcare staff are actively involved in the development of IPC-related interventions, an approach termed as 'co-design'. Along with staff's involvement, interventions should be developed on a holistic learning perspective (Kolb's experiential learning theory). They, also, recommended using lab simulations implementing biosphere to visually depict the spread of pathogens. They finally highly agreed that habit formation and making the intervention easy to be incorporated into everyday practice are essential elements towards successful interventions. How do these recommendations sound to you? Are they in the right direction to facilitating your team's HH practices?	- *Would you explain that further?* - *What does anyone else think?*	
What, if any, suggestions you would like to make regarding the development of such interventions?	- *Can you give an example?* - *Could you provide with more details on that?* - *What does anyone else think?*	

CONCLUSION

This is me finished me with the questioning. Is there anything else I did not ask and you would like to add? Thank you once again for your time and your valuable input.

Focus group discussion concluded at (specify end time):

CLOSE OF FOCUS GROUP DISCUSSION

Appendix 17 – Invitation poster used to recruit focus group participants

(Note that the posters for the remaining focus group discussions included slight variations in wording as appropriate)

Participants Needed

Would you like to take part in a **focus group discussion** aimed at promoting infection prevention and control and improving hygiene practices related to healthcare-associated infections?

The focus group discussion will consist of an easy-going conversation among six to ten people of similar occupational background.

The focus group discussion will be held: **Venue**: [Name of NHS Trust and Hospital] and will require approximately **1 hour of your time**

If you are:
✓ A registered nurse
We would like to hear from you.

When?: 24th July, 2018 at 2pm

Snacks and light refreshments (including Greek specialties) will be provided.

For more information or to sign up please contact:
Kostas Tsattalios (PhD candidate)
k.tsattalios@rgu.ac.uk

ROBERT GORDON UNIVERSITY ABERDEEN

Appendix 18 – Participant information sheet in focus group discussions

INFORMATION SHEET FOR PARTICIPANTS

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title: Facilitating Adherence to Hygiene Policies in Infection Prevention and Control: Considering the Role of Theory and Visualisations in Behaviour Change Interventions

We would like to invite you to participate in this doctoral research project. We regard it to be of potential importance but you should only participate if you wish to. Opting not to participate will by no means affect you in any way. Before deciding whether you wish to participate, it is essential for you to understand why the research is being conducted and what your participation will involve. Please, take time to read this information carefully and discuss it with others shall you wish. Do ask us if there is anything that is not clear or if you would like more information.

Background and purpose of the study

As you already know based on your academic training and clinical experience, hygiene practices play a crucial role in infection prevention and control (IPC). However, despite its importance, adherence by healthcare staff remains at unsatisfactory levels across the globe. Failure to adhere results in increased and persistent rates of healthcare-associated infections (HAIs) which affect patients, visitors and healthcare staff linked with alarming morbidity and mortality rates as well as high financial losses for the healthcare system [1].

Recognising that healthcare staff have a central role in IPC, it is essential to identify those factors that promote (facilitators) and hinder (barriers) adherence to hygiene regulations. Many of these factors may be usefully explained and influenced through use of relevant theory, particularly as a basis for the development of educational interventions, training programmes and relevant campaigns. In addition, within such initiatives to help address HAIs, *visualisations* (e.g. colour posters, visual reminders, video clips) are often used as contributory or central components. Importantly, visualisations are more dynamic and memorable (than traditional approaches e.g. information textual-based leaflets) and their use appears to facilitate IPC-related behaviours (e.g. handwashing) [2].

Considering the significance of theory and visualisations in the development of IPC-related interventions, the purpose of this focus group discussion is two-fold: firstly, to identify what factors in your opinion act as barriers and facilitators in relation to IPC and what types of visualisations do you recall encountering as part of your education and/or clinical practice, and secondly, to discuss the recommendations provided by key experts (a study conducted at a previous stage of this research) regarding the optimal combination of theory and visualisations and whether or not the suggested recommendations would facilitate your IPC practices.

Armed with your opinions and views, we aim to develop guidelines geared towards researchers which are anticipated to increase the chances that they use the optimal combination of theory and visualisation for the development of IPC-related interventions. This focus group study is part of an ongoing doctoral research dissertation generously funded by Robert Gordon University.

Why have I been invited?

As a healthcare professional your role in IPC is very important. Your experiences, views and opinions are therefore very relevant to the research project and will provide us with insights as to how to best develop IPC-related behaviour change interventions combining theory and visualisations. Finally, we hope that participating in this discussion and engaging with peers will be a reflective and interesting opportunity to you personally.

Do I have to take part?

No, your participation is totally voluntary and it is up to you to decide whether or not to participate. If you decide to take part you will be asked to complete and return a consent form. If you initially agree to participate, but then decide to withdraw then this is fine. In this case, please tell the lead researcher (Kostas Tsattalios, School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG, tel: 07761889930, e-mail: k.tsattalios@rgu.ac.uk). Deciding not to participate will not affect your professional status in any way.

What will happen during the focus group discussion?

The focus group discussion will take place on ARI and will consist of six to ten registered nurses from the Royal Aberdeen Children's Hospital and it will take around one hour. The discussion will be facilitated by the lead researcher, Kostas Tsattalios, who will guide you through the issues which are planned to be explored. Such issues will refer to your experiences, views and opinions in relation to IPC, factors that promote or hinder adherence to hygiene regulations, the use of visualisations as part of interventions, educational programmes and campaigns. Also, a summary of suggestions given by key experts in healthcare and behaviour change research will be discussed with a focus on how theory and visualisations can best be combined. We are interested in listening to your thoughts in this topic and as such there are no right or wrong responses in a discussion of this nature. There will be comfort breaks if needed and snacks and light refreshments will be provided.

Will my taking part in the study be kept confidential?

The focus group discussion will be audio-recorded to ensure an accurate and timely transcription and analysis of the discussion. Please, note that your consent to be audio-recorded will be sought prior to the commencement of the focus group. You will not be asked to provide any private or confidential information and your quotes may be used in reports and publications to help illustrate the points made. However, quotes that might reveal your identity will not be used. Material gathered during this research will be coded and kept confidentially by the lead researcher with only the researcher and supervisory team having access. Paper material be securely stored in a locked cabinet and digital material in password protected PC files both within a restricted area of RGU for 10 years. Data will be treated in accordance with the UK Data Protection Act 2018 and as per Robert Gordon University's data protection policy.

Professor Paul Hagan, Robert Gordon University is the sponsor for this study based in the United Kingdom. We will be using information from you in order to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. Robert Gordon University will keep identifiable information about you for 10 years after the study has finished.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

You can find out more about how we use your information at https://www.rgu.ac.uk/research/university-research-policy. You can find out more about how patient information is used in health and care research from the Health Research Authority at www.hra.nhs.uk/information-about-patients.

Robert Gordon University will use your name, and contact details to contact you about the research study, and make sure that relevant information about the study is recorded to oversee the quality of the study. Individuals from Robert Gordon University and regulatory organisations may look at your research records to check the accuracy of the research study. The only people in Robert Gordon University who will have access to information that identifies you will be people who need to contact you to audit the data collection process. The people who analyse the information will not be able to identify you and will not be able to find out your name, or contact details.

Robert Gordon University will keep identifiable information about you from this study for 10 years after the study has finished.

Who has reviewed this study?

This focus group study is part of the lead researcher's doctoral research and has been reviewed and approved by the School of Nursing and Midwifery Ethics Review Panel (SERP) at Robert Gordon University (SERP reference: 18-15). Also, permission to conduct this focus group discussion was obtained by [Name of NHS Health Board] Research and Development (R&D) (R&D reference: XXX).

What will happen to the results?

The audio-recording will be transcribed by the lead researcher and analysed to identify common themes in what participants have said. The audio-transcripts will be stored on a secure server on a password-protected file at a Robert Gordon University computer. The audio transcripts will be kept there for 10 years and permanently destroyed after this period.

A summary report of the findings will be provided to participants upon request. Also, the findings will be disseminated in relevant conferences and published in peer-reviewed journals as appropriate. Upon completion of this doctoral research, the e-thesis will be available online on OpenAir, Robert Gordon University: https://openair.rgu.ac.uk/.

What if something goes wrong?

If participating in this focus group discussion has caused any discomfort to you, or if you want to complain about how it was conducted, you can contact my principal supervisor Dr Colin Macduff (e-mail: c.macduff@rgu.ac.uk).

What do I do now?

If you wish to take part in this focus group discussion or if you wish to ask any further questions, please contact myself, Kostas Tsattalios (tel.: 07761889930, e-mail: k.tsattalios@rgu.ac.uk).

Thank you for taking the time to read this Information Sheet.

Indicative bibliography

1. Trybou, J., Spaepen, E., Vermeulen, B., Porrez, L., & Annemans, L. (2013). Hospital-acquired infections in Belgian acute-care hospitals: financial burden of disease and potential cost savings. *Acta Clinica Belgica*, 68(3), 199-205.
2. Murray, J., Williams, B., Hoskins, G., Skar, S., McGhee, J., Treweek, S., ... & Cameron, L. (2016). A theory-informed approach to developing visually mediated interventions to change behaviour using an asthma and physical activity intervention exemplar. *Pilot and feasibility studies*, *2*(1), 46.

Appendix 19 – Consent form in focus group discussions

ROBERT GORDON UNIVERSITY ABERDEEN

FOCUS GROUP CONSENT FORM

Title*:* Facilitating Adherence to Hygiene Policies in Infection Prevention and Control: Considering the Role of Theory and Visualisations in Behaviour Change Interventions
Lead researcher: Kostas Tsattalios

Please initial box

7. I confirm that I have read and understood the participant information sheet explaining the above research project and I have had the opportunity to ask questions about the project and have had these answered satisfactorily.

8. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions I am free to decline.

9. I agree to have the focus group audio-recorded, so it can be transcribed after the focus group is held.

10. I am fully aware that data collected will be stored securely, safely in premises of Robert Gordon University and in accordance with Data Protection Act (2018) with only myself and supervisors having access to them when necessary. Data will be retained for up to 10 years and will be destroyed when it is no longer needed for the project.

11. I agree for the data collected from me to be used in an anonymised and unidentifiable form in future research and/or disseminated (e.g. conference presentation, journal publication)

12. I agree to take part in this study.

Name of Participant	**Date**	**Signature**
Name of Lead Researcher	**Date**	**Signature**

<u>Contact Information</u>

This research has been reviewed and approved by the School of Nursing and Midwifery Ethics Review Panel at Robert Gordon University (SERP reference: 18-15) and by the Research and Development (R&D) department of [name of NHS Health Board] (R&D reference: XXX). If you have any further questions or concerns about this study, please do not hesitate to contact the lead researcher:

Mr Kostas Tsattalios
School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG
Tel: 07761889930
E-mail: k.tsattalios@rgu.ac.uk

What if I have concerns about this research?

If you are worried about this research, or if you are concerned about how it is being conducted, you can contact my principal supervisor:

Dr Colin Macduff, Visiting Reader
School of Nursing and Midwifery, Robert Gordon University, Garthdee, Aberdeen, AB10 7QG
E-mail: c.macduff@rgu.ac.uk

YOU WILL RETAIN ONE SIGNED COPY OF THIS CONSENT FORM

Appendix 20 – Example of coding participants’ extracts for question 1 of the topic guide for both focus group types

Codes from IPC teams		**Codes from paediatric nurses**
-Use of local polices -Use of national policies -Use of international polices -Use of HH policies -Components of IPC polices -Use of online manual to access IPC polices -Use of policies to educate staff -Policies guided by standard infection control precautions -Cascade training based on training -HAI-specific policy -Busyness of staff influencing IPC practice -Time constraints influencing IPC practice -Pressures and demands owing to ageing population -Lack of understanding in the consequences of not undertaking HH -The importance of ‘why’ to do something in relation to IPC -No consequences perceived of not doing HH after leaving patient’s environment -Questioning part of policies -Prioritisation of patient care -Importance to have evidence to facilitate compliance -Understanding staff’s non compliance -Inability to provide evidence for performing aspects for IPC practice -Questioning the effectiveness of HH -Frustration by senior charge nurses owing to non-compliant doctors -Infection control often seen as an add on rather than embedded in daily practice -A significant incident could affect infection control -Competing priorities -Extra paperwork as a hindrance to infection control -The role of behaviour and attitude in IPC -Importance of evidence for medical staff for performing IPC practice -Nursing staff less critical than medical staff -Education through HH audits as an intervention -Planning and actions taken for non-compliant results -Actions taken to improve compliance among staff -Monthly HH audit visits -Making IPC straightforward and integral part of care for all staff -Random selection of wards for HH audits -Audit emphasis on providing knowledge and wards taking control -Mutual agreement and consistency on classing a HH moment -Adherence to flow chart during audits -Action plan and re-audit -Involvement of management in improving compliance	Question about: Adherence to hygiene policies/recommendations	-Use of 5 moment of HH -Health policy of the Trust -Education influencing HH -Availability of facilities and resources influencing HH -Practice has changed over the decades -Importance of education -Use of online educational resources -Use of HH audit -Availability of facilities and resources -Use of individuals gel bottles -Directing people towards IPC practice -Issues with facilities -Behaviour as a habitual process -Use of stickers on gel hand rubs -IPC behaviour irrespective of interventions -Presence of signs does not lead to hand washing -Posters showing pathogens on hands attracting attention -Relate visuals to the disease process -Ineffectiveness of ‘ready, steady, go’ posters -Interactive vs static visualisations -Ignoring posters -IPC practice between experienced and junior members of staff -Policies used for HH -Examples of HH policies -Hospital unit’s policies -Actual frequency of hand washing -Washing hands too many during the day -Make policies fit in everyday practice is challenging -Constant hand washing -Being OCD about hand washing -Worries of making patients sick -High rates of infections -Importance of washing hand many times -Effect of soap on skin -Hands breaking down -Harsh soap -Not trying hands properly -Drying hands linked to education -Lack of time to dry hands properly -Becoming more vigilant with hand washing -Reminding colleagues to wash hands -Students being conscious of hand washing

Codes from IPC teams (continued)		**Codes from paediatric nurses** (continued)
-Educational interventions in place -Use of didactic style education -Examples of educational interventions currently used -Staff not assimilating in practice educational approaches -Education of staff as an ongoing process -Intervention coverage of various hospitals -Use of inductions for new staff -Intervention-event -Application of policies differs from place to place -Audit scores inconsistencies between IPC teams and ward teams audits -Questioning the effectiveness of current educational interventions -Educational IPC practices packages -Calling a meeting as an intervention -Importance for staff to take ownership of their choices -Belief that staff do not know the role of the infection control team -Education often seen as tick box exercises by staff -Absence of staff challenging colleagues to perform IPC practices -Importance of learning by example -Patients involvement in interventions -Intervening by highlighting proper IPC practice -The presence of the IPC team members as an intervention -Management expect the IPC team to reduce infection rates -The IPC team can only enable staff towards reducing infection rates -The tiered healthcare system as a challenge to IPC practice -Education intervention needs to be seen as a mindset -All healthcare staff as role models not only the IP team -Importance for management to reinforce IPC team's messages -Staff' engagement in IPC practice is key -Discussion with staff after observational audits -Doctors seen as engaging the least with role modelling -Permanency and rotation in post influence staff's ownership -Recognition of engaging and vigilant doctors with IPC practice -Unnecessary hand washing -Availability of hand gels at points of patient care -Easy and accessible to increase hand washing -Use of personal hand gels -Need for having cleaning staff in each ward -Usefulness of more staff on a bigger scale is questioned -Need for reducing paperwork -IPC is a small part of staff's routine -Ineffectiveness of quality assurance care of equipment -Not to blame staff -Activities other than IPC-related	Question about: **Adherence to hygiene policies/recommendations**	-Being overcautious with hand washing -Posters as interventions -HH audits as an intervention -Audits are fancier that posters -Education and induction as intervention -Never looking at posters -Too many posters everywhere -Posters ignored -Reversal of staff behaviour after audit -Understanding the consequences of behaviour -contribution of patients' parents in IPC practice -Parents involved in auditing