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Features of educational interventions that lead to compliance with hand hygiene in healthcare professionals within a hospital care setting. A BEME systematic review: BEME Guide No. 22

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Abstract

Background: In the United Kingdom, there are approximately 300,000 healthcare-associated infections (HCAI) annually, costing an estimated £1 billion. Up to 30% of all HCAI are potentially preventable by better application of knowledge and adherence to infection prevention procedures. Implementation of Department of Health guidelines through educational interventions has resulted in significant and sustained improvements in hand hygiene compliance and reductions in HCAI.

Aim: To determine the features of structured educational interventions that impact on compliance with hand hygiene in healthcare professionals within a hospital care setting.

Methods: Sixteen electronic databases were searched. Outcomes were assessed using Kirkpatrick's hierarchy and included changes in hand hygiene compliance of healthcare professionals, in service delivery and in the clinical welfare of patients involved.

Results: A total of 8845 articles were reviewed, of which 30 articles met the inclusion criteria. Delivery of education was separated into six groups.

Conclusions: It was not possible to identify individual features of educational interventions due to each study reporting multicomponent interventions. However, multiple, continuous interventions were better than single interventions in terms of eliciting and sustaining behaviour change. Data were not available to determine the time, nature and type of booster sessions with feedback needed for a permanent change in compliance.

Background

Nosocomial infections (or healthcare-associated infections (HCAI)) are infections that occur within 48 hours of admission to hospital or within 30 days of discharge, which happen as a result of healthcare treatment. Infections can be transmitted from a colonised healthcare professional (a qualified individual who delivers professional health care in a systematic way to any individual in need of healthcare services) to a susceptible patient as a result of direct physical contact, such as when bathing or caring for a patient (direct-contact transmission) or transmitted from a colonised object to a susceptible patient, such as needles or gloves (indirect-contact transmission). The most common organisms transmitted via direct-contact transmission are *Clostridium difficile* (Whitaker et al. 2007) and methicillin-resistant *Staphylococcus aureus* (MRSA; Larson et al. 2000; Gill et al. 2009). The most commonly acquired HCAI are urinary tract infections, surgical site infections (including MRSA) and pneumonias (including ventilator-associated pneumonia; Reilly et al. 2007).

In the United Kingdom, there are at least 300,000 HCAI annually costing an estimated £1 billion per year (National

Practice points

- Taking part in any structured educational intervention designed to improve hand hygiene compliance in a hospital environment is likely to be effective in improving practice.
- Combining an educational intervention with other components (reminders, incentives, checklists, surveillance, audit and feedback) is the most effective way of reinforcing the educational message.
- Repeated sessions feed into daily practice will maintain compliance.
- The first step to improving hand hygiene compliance should be to target educational interventions in areas where compliance to best-practice is poorest.
- Consider using performance feedback when educating healthcare professionals. Performance feedback in the form of performance reports or the use of UV technology is likely to increase hand hygiene compliance.
- Ensure that hand washing practices become intrinsic within professional practice by using internal teams to deliver interventions rather than external sources.

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Audit Office 2004). These infections result in longer hospitalisation (2.5 times longer than uninfected patients), disability and death (National Audit Office 2004). In 1995, a Department of Health working party on infection prevention in hospitals suggested that 'in the United Kingdom, 5000 deaths (1% of all deaths) might be primarily attributable to HCAI, and in further 15,000 cases (3% of all deaths) HCAI might be a substantial contributor (Department of Health 1995)'. The same working party suggested that up to 30% of all HCAI were potentially preventable by better application of knowledge and adherence to infection prevention procedures. A more recent national study of HCAI in England, Wales and Ireland identified prevalence in adult patients of 7.59% (range 0–34.6%; Smyth et al. 2008). HCAI have been estimated to result in 25 million additional patient days in hospital annually, costing €13–24 billion annually (World Health Organization 2009). Prevalence of HCAI in the United States is similar to that in the United Kingdom when population size is adjusted for; two million HCAI are estimated to occur annually, resulting in approximately 90,000 deaths (Safdar & Abad 2008) and costing up to $5.7 billion per year.

The importance of hand hygiene in medicine in reducing disease transmission within hospital environments was first recognised in the nineteenth century by Semmelweis (1983). As a result, hand hygiene is now recognised as the main intervention for reducing nosocomial infections within medical settings (Larson 1995). Hands become contaminated during episodes of care, both from the patients and the environment (Pittet et al. 2006). Without adequate decontamination the level of bacterial contamination increases with time (Pittet et al. 1999a), potentially allowing transfer to other patients or further contamination of the environment. Hand hygiene refers to the minimisation of disease spread and/or progression through cleansing hands of pathogenic microorganisms, including bacteria and viruses. Effective hand hygiene has been recognised as one of the most important measures for preventing the spread of pathogens (Centers for Disease Control and Prevention 2002), and, coupled with the use of antiseptic chemicals (e.g. in soap) and alcohol gel, can reduce the spread of antibiotic-resistant organisms (World Health Organization 2009).

Guidance for hand hygiene has been incorporated into evidence-based practice (National Institute for Clinical Excellence 2003) and legislation for all healthcare professionals within the United Kingdom (Department of Health 2006). The recognition of the importance of compliance with hand hygiene resulted in the implementation of a national campaign in the United Kingdom in 2005 (the National Health Service (NHS) National Patient Safety Agency (NPSA)). Headed by the NPSA, the 'clean**your**hands' campaign actively promotes hand hygiene. Evaluation of the campaign has demonstrated improvement in overcoming physical barriers and compliance, as measured by consumption of hand hygiene products. The most recent update from the NPSA, 'clean hands save lives', was published in September 2008 and highlights the role of healthcare professionals in hand hygiene.

In addition, hand hygiene is the principal focus of the World Health Organisation's First Global Patient Safety Challenge (World Health Organization 2009). One component of this programme is the 'save lives: clean your hands', a global action day launched in 2009. Every 5 May, hospitals registered to the scheme (12,394 in February 2011) provide their staff with various educational events (such as videos and displaying posters) which aim to increase awareness and compliance with hand hygiene. Guidelines for hand hygiene in the United States were published in 1981 by the Centres for Disease Control and Prevention. These were revised in 1988, 1995 and most recently in 2002 (Centers for Disease Control and Prevention 2002). This revision includes recommendations for the use of alcohol hand hygiene products for patient care, given research suggesting increased compliance with hand hygiene when alcohol-based rub is available (Stone et al. 2007).

However, competence in hand hygiene is not the same as compliance with recommended practice; a healthcare professional can be competent at washing their hands but this may not translate into compliance within everyday practice. Competence encapsulates healthcare professionals' ability to wash their hands effectively and remove pathogens from their hands using guidance such as that published by the NPSA in the United Kingdom (National Patient Safety Agency (NPSA) 2008). Compliance focuses on healthcare professionals' ability to wash their hands at the recommended points of clinical contact. Indeed, since all healthcare professionals must undertake mandatory training and assessment in hand hygiene annually, one may assume that most of them are competent at the point of initial assessment. However, the infection rate in hospitals indicates that they do not comply with standards and guidelines (Erasmus et al. 2010). Whilst there is a well-researched evidence base and clear clinical guidelines as to the most effective method to decontaminate hands, less is known about the most effective ways to promote compliance with hand hygiene in healthcare professionals.

Compliance with hand hygiene is necessary for all healthcare professionals and ancillary staff working within hospital settings. Of these professionals, doctors and nurses make up the largest proportion. Significant variability between healthcare professionals of up to 22% between ancillary staff and nurses following implementation of a hand washing protocol has been reported (Rosenthal et al. 2005). In addition, poor compliance to recommended hand hygiene practices has been associated with being a physician rather than a nurse, male rather than female, working during the week rather than at the weekend, the wearing of gowns/gloves, automated sink use, clinical practices with high risk of cross transmission and a high number of opportunities for hand hygiene per hour of patient care (Boyce & Pittet 2002). Medical students and doctors have been reported to have the lowest rates of compliance with hand hygiene, with 41% of opportunities for hand decontamination resulting in noncompliance. They were followed by porters at 38%, technicians and physiotherapists at 33%, nurses at 28% and healthcare assistants at 21% (NHS National Patient Safety Agency Cleanyourhands Campaign).

Most research studies evaluating the effectiveness of educational campaigns to promote hand hygiene practices focus on the compliance of healthcare staff, which has been found to be variable (Thompson et al. 1997; Pittet et al.

1999b). The American National Guidelines published in 2002 (Centers for Disease Control and Prevention 2002) suggest an average compliance of 40% and lists a number of factors that influence adherence such as insufficient time, lack of knowledge and lack of personal or institutional priority. Research indicates that compliance may vary between healthcare settings and between different units in the same setting (Creedon et al. 2008) with perversely worse compliance in intensive care units (ICU; Pittet et al. 1999b; Eveillard et al. 2009).

The World Health Organisation's recommendations for developing an educational intervention (World Health Organization 2009) describe steps that are based on available evidence and expert opinion. It is recommended that interventions meet the requirements of the healthcare faculty, to enable the infection control team to focus on areas requiring modification; interventions are categorised depending on current practice; baseline compliance rates are measured before the implementation of new guidelines; different types of compliance, such as the use of hand gel should be assessed and interventions should be formulated and executed based on the resistance factors of healthcare professionals (World Health Organization 2009).

Increased compliance with hand hygiene has been found to be influential in significantly reducing infections rates in the United Kingdom (Schelenz et al. 2005) and the United States (Larson et al. 2000). It is therefore necessary to identify the individual components of successful educational interventions in order to produce transferrable, effective interventions to improve compliance with hand hygiene within a hospital care setting. This is particularly important as educational interventions are a frequently used and core method of disseminating knowledge within health care (Cherry et al. 2010). As yet, no published researched has investigated the impact of individual features of educational interventions on compliance with hand hygiene practice in healthcare workers; this is a particularly pertinent research topic given research suggesting the impact of increase hand hygiene compliance on patient infection rates.

In addition, no previous systematic reviews considering the effectiveness of individual features of educational interventions to improve compliance with hand hygiene within a hospital care setting were identified in searches of the published literature conducted for this review. Several systematic reviews have considered the effectiveness of education in reducing nosocomial infections. Safdar & Abad (2008) reviewed educational interventions to prevent HCAI and concluded that educational interventions may reduce HCAI considerably. A systematic review by Mathai et al. (2010) looked at educational interventions to improve hand hygiene but did not explicitly focus on compliance, and found that healthcare professional education has a positive impact on improving hand hygiene and reducing healthcare-associated infection. Aboelela et al. (2007) considered the effectiveness of bundled behavioural interventions on reducing HCAI. This review did not solely focus on educational interventions, but included studies using educational programmes, multidisciplinary quality improvement team, compliance monitoring and feedback and a mandate to sign a hand hygiene agreement. As bundles of interventions were used, they concluded that it was difficult to determine the effectiveness of individual interventions. Despite this literature base, no review has to date evaluated or identified individual features of education that have the most profound and long-term impact on aseptic hand hygiene practices.

Review aims

The aim of this review was to determine the effectiveness of individual features of structured educational interventions (educational processes designed to increase, improve or enhance the hand hygiene performance of healthcare professionals) that impact on hand hygiene compliance and associated changes in clinical welfare of patients within hospital care settings.

Methods

Identification of studies

The search was divided into two sections – an electronic search of 16 relevant health and educational databases, and augmentation of this search using hand searching of high-yield journals and screening of reference lists of included papers and relevant systematic reviews. The search incorporated a number of strategies, combining index terms and free text words. The search strategies had no language restrictions and did not include methodological filters that would limit results to a specific study design. All references were exported to an EndNote bibliographic database.

Electronic databases were chosen to span clinical and educational databases. The following electronic databases

Table 1. Inclusion criteria.

Study design	All study designs considered. Studies conducted and published from 1995 onwards included.
Population	Healthcare professional participants OR Contained one or more of the above groups for which results were recorded separately.
Educational intervention	Content documentable and repeatable. Run over defined time period. Structured and educational Interventions designed to change staff behaviour with regards to compliance of one or more facet of hand hygiene.
Comparator	Any, including but not limited to use of a control group, a differing educational intervention and use of differing healthcare groups.
Outcome measures	At least one outcome measure of aseptic hand hygiene. Study reports pre and post intervention data relating to either patient outcomes or staff behavioural change Reports adequate descriptive statistics to evaluate the effectiveness of an intervention
Setting of study	Studies carried out within a hospital care setting settings considered.
Follow-up period	At least 6 months

Table 2. Krkpatrick's Hierarchy (1967).

Level 1: Reaction
This covers learner's views on the delivery and content of the educational intervention. This may take the form of verbal or written feedback immediately after the delivery of the intervention, and includes learner's views on presentation, organisation, content, teaching methods, time-tabling, materials used and quality of teaching.

Level 2a: Modification of attitudes and perceptions
This relates to any changes in reciprocal attitudes or perceptions between participant groups. This includes any changes in perceptions or attitudes by participants towards the value and/or use of the taught approach to caring for patients, and their condition, circumstances, care and treatment.

Level 2b: Acquisition of knowledge and skills
For knowledge, this relates to the acquisition of concepts, procedures and principles of hand hygiene as a direct result of the delivery of the educational intervention.For skills, this relates to the acquisition of thinking/problem-solving, psychomotor and social skills linked to hand hygiene as a direct result of the delivery of the educational intervention.

Level 3: Behavioural change
This relates to the transfer of principles of aseptic hand hygiene to the workplace, such as support for change in behaviour in the workplace, or willingness of learners to apply knowledge and skills about hand hygiene, obtained as a direct result of the delivery of the educational intervention, to their practice style.

Level 4a: Change in organisational practice
This relates to wider changes in the organisation/delivery of care, attributable to the delivery of an education intervention. These changes may be financial or organisational.

Level 4b: Benefits to patients/clients, families and communities
This relates to any improvements in the health and well being of patients as a direct result of the delivery of an educational intervention. Where possible, objectively measured or self reported outcomes will be used, including but not limited to health status measures, infection incidence, duration or cure rates, mortality rates, complication rates, readmission rates, continuity of hand hygiene and costs to carer or patient. These outcomes will be further determined by the literature found.

were searched for relevant published literature for the period 1995 to March 2011: The Cochrane Library; EMBASE; Health Technology Assessment database; ISI Web of Science-Proceedings (Index to Scientific & Technical Proceedings) and Science Citation Index Expanded; MEDLINE; CINAHL; PsycINFO; BNI; HMIC; Database of Abstracts of Reviews of Effectiveness; NHS Economic Evaluation Database; ERIC; National Research Register; COPAC; Open SIGLE and British Library Catalogue.

Selection of evidence

Inclusion and exclusion criteria are described in Table 1. The records identified in the electronic searches were assessed for inclusion in two stages. Two reviewers (N.J.S. and M.G.C.) independently scanned all titles and abstracts identified in the search to identify reports which could have been relevant to the clinical review. Full text versions of all records selected during the initial screening process were obtained to permit more detailed assessment and to minimise the risk of missing relevant papers. These were assessed independently by two reviewers (J.G. and G.C.), using the inclusion and exclusion criteria shown in Table 1.

The inclusion/exclusion assessment of each reviewer was recorded on a pretested, standardised form. Disagreements were resolved by discussion, and if necessary, another reviewer was consulted.

Data extraction. Data were extracted from each full text paper. A random sample of 20% of studies was doubly coded to ensure that appropriate, consistent and matching data were collected. Five discrepancies were found between reviewers, for which a third member of the review team was consulted. It was therefore deemed appropriate for one individual (M.G.C.) to singly code all papers and for another (N.J.S.) to check all data extraction for consistency. Data were entered into Microsoft Excel.

Quality assessment. Quality of included papers was assessed by two reviewers (M.G.C. and N.J.S.) using a tool adapted from Downs (Downs & Black 1998). Where no data were present, for example relating to group size, this was scored as 'not reported' rather than 'not present', and a quality score was calculated as a percentage to allow for as adequate a comparison between studies as possible.

Methods of data analysis and synthesis. The relevant outcome measures from each primary paper were extracted and assessed based on modified Kirkpatrick's 1967 model of hierarchical outcomes (Kirkpatrick 1967) at four levels, as illustrated in Table 2. Additional predetermined or secondary outcome measures were also accepted and recorded.

Results

Number of studies identified and included

The database search identified 11,697 articles (8845 after duplication), with the hand search yielding a subsequent 29 studies. The full text of 204 papers (2.3% of the initial cohort) was obtained and independently reviewed by two members of the review team (M.G.C. and N.J.S.). Opinion as to suitability was divided on four papers, and consensus from a third member (J.M.B.) was sought. From this discussion, 30 studies were identified as fulfilling all inclusion criteria and therefore suitable for inclusion in the review. Study characteristics are presented in Table 3.

Quality assessment of included studies

The methodological quality of the included papers is summarised in Table 3. Overall, methodological reporting and quality was inconsistent. The intervention implementation strategy was often poorly reported. Few studies reported sufficient detail about study design and there was often insufficient reporting of length of follow-up for numerous

Table 3. Characteristics of included studies.

Author	Country of study	Study period	Main outcome measure	Preintervention	Postintervention	Length of follow-up (months)	Type of intervention	Study setting	Participant group	Alcohol gel included in intervention	Any additional component	Kirkpatrick level	Quality assessment score
Benton 2007	USA	January 2004–January 2005	Compliance with hand hygiene	17%	78.1%	6	Education, multimodal with self-study	Hospital wound care centre	Doctors	Y		3	71
Bhutta et al. 2007	USA	1998–2005	CVC primary bloodstream infections	9.7/1000 CVC days	3.0/1000 CVC days	36	Education, multimodal with video	One paediatric ICU (19 beds)	Not specified	Y	Interventions designed for CVC insertion and maintenance. Stepwise introduction of interventions, including maximal barrier precautions, change in skin disinfectant and use of antibiotic impregnated catheters.	3 and 4b	60
Buffet-Bataillon et al. 2010	France	2006–2007	Compliance with hand hygiene	44.9	58.0	12	Education, multimodal with demonstration	Tertiary hospital	All healthcare professionals	Y	Compliance improved in nursing staff but decreased in doctors and nursing auxiliary workers	3	82
Conrad et al. 2010	Germany	January 2003–July 2008	MRSA rates	0.19/1000 patient days	0.12/1000 patient days	37	Education, multimodal	Various departments in a tertiary hospital	Nurses and doctors	Y		4b	71
Danchaivijitr et al. 2005	Thailand	January 2004–July 2004	Compliance with hand hygiene	4.5%	13.4%	34	Education, multimodal	Neonatal ICU	All healthcare professionals	Y	Data only taken from the one hospital that had a longer follow-up than 6 months	3	75
Dierssen-Sotos et al. 2010	Spain	October 2006–October 2007	Compliance with hand hygiene	40.5%	46.1%	12	Education, multimodal	Three hospitals	All healthcare professionals	Y		3	71
Doron et al. 2011	USA	September 2007–February 2009	Compliance with hand hygiene	90%	96%	11	Education, multimodal	Hospital	All healthcare professionals	N	Ward culture was considered when developing intervention. Feedback included within intervention.	3 and 4b	60
Gill et al. 2009	The Philippines	May 2003–August 2004	Risk of death	Risk of death per 1000 admissions: 290	Risk of death per 1000 admissions: 144	10	Education, multimodal with video	Two NICUs	All healthcare professionals	Y		3 and 4b	86
Grayson et al. 2008	Australia	October 2004–September 2006 (pilot) March 2006–March 2007 (secondary)	Compliance with hand hygiene	20%	49%	12	Education, multimodal with demonstration and video	Pilot- 6 healthcare institutions, secondary all public hospitals in Victoria	All healthcare professionals	N		3 and 4b	68

Helder et al. 2010	Netherlands	June 2003–December 2006	Nosocomial infection rate	17.3/1000 patient days	13.5/1000 patient days	18	Educational, multimodal with self-study	Level IIID NICU	Nurses and doctors	Y		4b	71
Helms et al. 2010	USA	July 2007–June 2008	Compliance with hand hygiene	66%	93%	12	Educational, multimodal with self study	All departments of 1 hospital	All healthcare professionals	Y		3	79
Huang et al. 2002	China	September 2000–January 2001	Compliance with hand hygiene.	40%	60%	24	Education, multimodal with demonstration	General hospital-nurses form all departments including medical and surgical wards, operating rooms, central supply room, ICU, dialysis centre, OBGYN.	Nursing staff	N	Educational intervention also looked at needle stick and sharps injuries training	2 and 3	96
Johnson et al. 2005	Australia	May 2001–May 2004	Compliance with hand hygiene	21%	42%	12	Education, multimodal with online elements	6 acute-surgical wards, ICU, renal unit and spinal injuries unit, then expanding to whole hospital	All healthcare professionals	N	In response to an outbreak of MRSA. Stepwise introduction of interventions	3 and 4b	79
Lam et al. 2004	China	19 months (duration not specified)	Compliance with hand hygiene	40%	53%	6	Education, multimodal with self-study	Neonatal ICU (12 bed)	All health professionals	Y		3 and 4b	82
Larson et al. 2000	USA	August 1997–December 1998	MRSA rates	0.464/1000 patient days	0.309/1000 patient days	6	Education, multimodal	Two hospitals	All health professionals	Y	Uses academic detailing to disseminate intervention	3 and 4b	85
Lederer et al. 2009a, b	USA	January 2006–December 2008	Compliance with hand hygiene	50%	>95%	35	Education, multimodal	Seven acute care facilities	All health professionals	N	Uses 'compliance monitors' and feedback in addition to education.	3 and 4b	60
Lobo et al. 2010	Brazil	January 2005–January 2007	Compliance with hand hygiene and Central venous catheter bloodstream infection rates (CVC-BSI)	6% (hand hygiene compliance lowest figure) 16.2 CVC-BSI rate (highest)	48% (hand hygiene compliance lowest figure) 13.7 CVC-BSI rate (highest)	9	Education, multimodal	Two medicals ICUs	All healthcare professionals	Y	Interventions were designed to reduce CVC-BSI rate by education of the whole procedure of CVC insertion including compliance with hand hygiene	3 and 4b	100
Lobo et al. 2005	Brazil	2002	CVC primary bloodstream infections	20/1000 CVC days	11/1000 CVC days	8	Education, multimodal with demonstration	One medical ICU	Medical residents and nurses	N	Intervention designed for CVC insertion and maintenance	3 and 4b	92
Muto et al. 2000	USA	2 months (duration not specified)	Compliance with hand hygiene	60%	52%	60	Education, multimodal	One medical ICU and one step-down unit	13 physicians,42 nurses, 17 technicians and 2 housekeepers	N		3	79

(continued)

Table 3. Continued.

Author	Country of study	Study period	Main outcome measure	Preintervention	Postintervention	Length of follow-up (months)	Type of intervention	Study setting	Participant gro up	Alcohol gel included in intervention	Any additional component	Kirkpatrick level	Quality assess-ment score
Picheansathian et al. 2008	Thailand	June 2004–February 2005	Compliance with hand hygiene	6.3%	81.2%	7	Education, multimodal	One paediatric ICU	26 nurses	N	Increase in NI. Doctors and other staff were not involved in study. Initial rating of compli-ance based on 20 observations only.	3 and 4b	70
Pittet et al. 2000	Switzerland	December 1994–December 1997	Compliance with hand hygiene	32%	63%	36	Education, multi-modal with demonstration	Teaching hospital-all wards and departments	All healthcare professionals	N		3 and 4b	75
Rosenthal et al. 2009	USA	January 2006–May 2008	Compliance with hand hygiene	50%	93%	30	Education, multimodal	All departments of hospital	All healthcare professionals	Y		3	79
Rosenthal et al. 2003	Argentina	July 1998–July 2002	Compliance with hand hygiene	Hospital B: 24% Hospital C: 23.1%	Hospital B: 67.1% Hos-pital C: 69.4%	Hospital B: 24 month-s Hosp-ital A: 15 months	Education, multimodal	Three hospitals, one public and two private	All healthcare professionals	Y	Performance feedback was also included	3	79
Salemi et al. 2002	USA	April 1998–September 2000	Compliance with hand hygiene	19%	68%	23	Education, multi-modal with video	One medical sur-gical ICU and one CCU	Doctors	Y		3 and 4b	61
Schelenz et al. 2005	UK	September 2000–May 2003	MRSA rates	11.16/1000 patients	2.09/1000 patients	16	Education, multi-modal with demonstration	Adult cardiac sur-gical unit	All healthcare professionals	N	Intervention carried out in response to MRSA outbreak. Other components were involved, such as MRSA screening and iso-lation of MRSA patients.	4b	72
Sharek et al. 2002	USA	January 1998–November 1999	Compliance with hand hygiene	47.7%	85.4%	6	Education, multimodal	Paediatric ICU	All healthcare professionals	Y	Very small group of participants, so chose to report on those who had changed the most	3	79
Trautmann et al. 2007	Germany	2002–2006	MRSA rates	6.7/1000 patient days (SICU), 5.8/1000 patient days (MICU)	7.5/1000 patient days (SICU), 1.7/1000 patient days (MICU)	48	Education, multimodal	Community teaching hospital	All healthcare professionals	N	Intervention had multi-ple components, such as a written MRSA standard, use of surveillance, gowns and carts and feedback to staff about infec-tion rates. MRSA screening policy.	4b	72

Trick et al. 2007	USA	October 1999–December 2002	Compliance with hand hygiene	23% (hospital A), 30% (hospital B), 35% (hospital C)	46% (hospital A), 50% (hospital B), 435 (hospital C)	24	Education, multi-modal with self-study	Four hospitals (ICUs medical/surgical units, skilled care units, rehab unit)	All healthcare professionals	N	3 and 4b	82
Won et al. 2004	Taiwan	January 1997–August 2000	Compliance with hand hygiene	43%	80% (after education alone), 81% (after education and feedback)	40	Education, multimodal	Neonatal ICU	All healthcare professionals	N	3	70
Zhang et al 2010	China	May 2000–May 2008	Nosocomial infection rate	>12%	6%	96	Education, multimodal	Paediatric Nephrology unit	Nurses and doctors	Y	4b	71

Table 4. Format of education used.

Educational delivery	Studies using this form of education
Multimodal education with a demonstration	Buffet-Bataillon et al. (2010); Huang et al. (2002); Lobo et al. (2005); Pittet et al. (2000); Schelenz et al. (2005)
Multimodal education with no demonstration	Conrad et al. (2010); Danchaivijitr et al. (2005); Dierssen-Sotos et al. (2010); Doron et al. (2011); Larson et al. (2000); Lederer et al. (2009a, b); Lobo et al. (2010); Muto et al. (2000); Picheansathian et al. (2008); Rosenthal et al. (2003, 2009); Sharek et al. (2002); Trautmann et al. (2007); Won et al. (2004); Zhang et al. (2010)
Multimodal education with a self-study module	Benton (2007); Helder et al. (2010); Helms et al. (2010); Lam et al. (2004); Trick et al. (2007)
Multimodal education with a video	Bhutta et al. (2007); Gill et al. (2009); Salemi et al. (2002)
Multimodal education with demonstration and a video	Grayson et al. (2008)
Multimodal education with an online element	Johnson et al. (2005)

studies. In addition, most studies did not provide data as to whether the intervention was mandatory or voluntary, and group size of participants was infrequently reported. Whilst no study was excluded from the review based on its quality, the quality was taken into account when drawing conclusions from these data.

Analysis of coded data from included studies

Demographics of included studies. Of the 30 included studies, 12 were based in the United States, three in China, two each in Thailand, Brazil, Germany and Australia and one each in The Philippines, The Netherlands, Switzerland, Spain, Argentina, the United Kingdom and Taiwan. Twenty-five studies contained both nurses and doctors (including post-graduate trainees) as participants, whilst two focused solely on doctors (Salemi et al. 2002; Benton 2007), two solely on nursing staff (Huang et al. 2002; Picheansathian et al. 2008) and one did not specify their participant group (Bhutta et al. 2007).

Outcome measures. Eleven studies solely measured a change in healthcare professionals' behaviour (Kirkpatrick level 3) as an outcome measure (Muto et al. 2000; Huang et al. 2002; Sharek et al. 2002; Rosenthal et al. 2003; Won et al. 2004; Danchaivijitr et al. 2005; Benton 2007; Rosenthal et al. 2009; Buffet-Bataillon et al. 2010; Dierssen-Sotos et al. 2010; Helms et al. 2010; Doron et al. 2011) and five solely measured change in patient outcomes (Kirkpatrick level 4b) as an outcome measure (Schelenz et al. 2005; Trautmann et al. 2007; Conrad et al. 2010; Helder et al. 2010; Zhang et al. 2010). Fourteen studies evaluated both change in healthcare professionals' behaviour (Kirkpatrick level 3) and change in patient outcome (Kirkpatrick level 4b) as outcome measures (Larson et al. 2000; Pittet et al. 2000; Salemi et al. 2002; Lam et al. 2004; Johnson et al. 2005; Lobo et al. 2005; Bhutta et al. 2007; Trick et al. 2007; Grayson et al. 2008; Picheansathian et al. 2008; Gill et al. 2009; Lederer et al. 2009a, b; Lobo et al. 2010; Doron et al. 2011). Of the 21 studies measuring change in healthcare professionals' behaviour as an outcome measure, all of them considered change in compliance with hand hygiene practices as an outcome measure (Muto et al. 2000; Pittet et al. 2000; Huang et al. 2002; Salemi et al. 2002; Sharek et al. 2002; Rosenthal et al. 2003; Lam et al. 2004; Won et al. 2004; Danchaivijitr et al. 2005; Johnson et al. 2005; Benton 2007; Trick et al. 2007; Grayson et al. 2008; Picheansathian et al. 2008; Lederer et al. 2009b; Rosenthal et al. 2009; Buffet-Bataillon et al. 2010; Dierssen-Sotos et al. 2010; Helms et al. 2010; Lobo et al. 2010; Doron et al. 2011). There was variation in outcome measures used. Of the 14 studies measuring change in patient outcomes, six used MRSA rates as the main outcome measure (Larson et al. 2000; Huang et al. 2002; Schelenz et al. 2005; Benton 2007; Trautmann et al. 2007; Lederer et al. 2009a, b; Conrad et al. 2010). The remainder looked at the broadly defined change in nosocomial infection rates (Helder et al. 2010; Zhang et al. 2010), risk of death per 1000 ICU admissions (Gill et al. 2009), catheter-related blood stream infections (Lobo et al. 2005; Bhutta et al. 2007; Lobo et al. 2010) and changes in rates of MRSA, vancomycin-resistant enterococci (VRE) and *Clostridium difficile* (Doron et al. 2011).

Educational delivery. From the analyses we identified several methods of educational delivery. The format of the education varied between studies, creating six groups of intervention. These six groups are: multimodal education with a demonstration, multimodal education with no demonstration, multimodal education with self-study module, multimodal education with a video, multimodal education with demonstration and a video and multimodal education with an online element. The format of education used in each study is shown in Table 4.

Educational Intervention 1: Education, multimodal with demonstration. Four studies measured behavioural change in healthcare professionals (Kirkpatrick level 3; Pittet et al. 2000; Huang et al. 2002; Lobo et al. 2005; Buffet-Bataillon et al. 2010), and three studies measured change in patient or organisational outcome (Kirkpatrick level 4b; Pittet et al. 2000; Lobo et al. 2005; Schelenz et al. 2005).

Demonstrations included those regarding the use of universal precaution techniques (Huang et al. 2002). Studies also contained other components, in addition to education for hand hygiene (Huang et al. 2002). Other components of the interventions included: needlestick and sharps training (Huang et al. 2002); the use of monitoring, feedback, closed wards, more gel gloves and aprons, screening and patient isolation (Schelenz et al. 2005); and performance feedback from the study in the form of a newsletter to all healthcare professionals (Pittet et al. 2000).

Educational Intervention 2: Education, multimodal without demonstration. Twelve studies measured behavioural change in healthcare professionals (Kirkpatrick level 3; Larson et al. 2000; Muto et al. 2000; Sharek et al. 2002; Rosenthal et al. 2003; Won et al. 2004; Danchaivijitr et al. 2005; Picheansathian et al. 2008; Lederer et al. 2009a, b; Rosenthal et al. 2009; Dierssen-Sotos et al. 2010; Lobo et al. 2010; Doron et al. 2011) and 10 measured change in patient or organisational outcome (Kirkpatrick level 4b; Larson et al. 2000; Sharek et al. 2002; Won et al. 2004; Trautmann et al. 2007; Picheansathian et al. 2008; Lederer et al. 2009a, b; Conrad et al. 2010; Lobo et al. 2010; Zhang et al. 2010; Doron et al. 2011). Of these studies, eight (Won et al. 2004; Danchaivijitr et al. 2005; Trautmann et al. 2007; Lederer et al. 2009a, b; Conrad et al. 2010; Lobo et al. 2010; Zhang et al. 2010; Doron et al. 2011) used performance feedback in addition to the education interventions. This performance feedback undertook several forms such as the use of ultra violet (UV) lamp technology (Conrad et al. 2010; Dierssen-Sotos et al. 2010) and newsletters regarding current compliance with hand hygiene (Lobo et al. 2010).

Educational Intervention 3: Education, multimodal, with self-study. Four studies measured behavioural change in healthcare professionals' compliance (Kirkpatrick level 3; Lam et al. 2004; Benton 2007; Trick et al. 2007; Helms et al. 2010) and two measured change in patient outcome (Kirkpatrick level 4b; Lam et al. 2004; Trick et al. 2007; Helder et al. 2010). The use of self study took many different forms such as one study used copies of policy documents and journal articles (Benton 2007); whilst another used a fact sheet and a promotional handout (Trick et al. 2007); and another required the healthcare professionals to produce a papers on the topic of hand washing if they were consistently found not to be complying to guidelines (Helms et al. 2010). Two of these studies (Helder et al. 2010; Helms et al. 2010) used UV lamp technology to provide performance feedback to the healthcare professionals on the effectiveness of their hand washing; this, however, is not a measured outcome in the studies as they focus on compliance rather than competence.

Educational Intervention 4: Education, multimodal with video. All the studies measured behavioural change in healthcare professionals (Kirkpatrick level 3) and change in patient or organisational outcome (Kirkpatrick level 4b) following educational interventions that included the use of video. One of the studies (Salemi et al. 2002) used educational feedback in addition to the components listed earlier in the text.

Educational Intervention 5: Multimodal education with demonstration and video. This study (Grayson et al. 2008) measured both behavioural change in healthcare professionals (Kirkpatrick level 3) and measured change in patient outcome (Kirkpatrick level 4b) following an educational intervention that involved video and demonstration.

Educational Intervention 6: Multimodal education with an online element. This study (Johnson et al. 2005) measured both behavioural change in healthcare professionals (Kirkpatrick level 3) and measured change in patient outcome (Kirkpatrick level 4b).

The intervention also contained the following components: feedback, incentives to staff members and consisted of four steps to intervention: alcohol/chlorhexidine **hand hygiene** solution (ACHRS), alcohol-impregnated wipes, mupirocin and triclosan body washes and a culture change program. There was also the use of performance feedback in this study as well as the use of educational interventions that took place in the form of providing senior staff with data from the study as it progressed. The outcome measures, Kirkpatrick levels and statistical significance of the studies within each group are summarised in Table 5.

Discussion

This systematic review aimed to identify individual features of educational interventions that impact on hand hygiene compliance in healthcare professionals within a hospital care setting. The results of this review provide medical and healthcare professionals, trainers, educationalists and educational researchers with practice points for implication of educational interventions within their institution. The inclusion of 30 studies with a follow-up period of more than 6 months illustrates the growth in literature pertaining to educational interventions for infection control within a hospital care setting.

The delivery of educational interventions related to hand hygiene compliance was divided into six groups in order to meet the aim of the review: multimodal education with a demonstration, multimodal education with no demonstration, multimodal education with a video, multimodal education with demonstration and a video, multimodal education with self-study module and multimodal education with an online element.

All interventions were multicomponent, and no study used an intervention consisting of only one mode of delivery. However, although we were able to discriminate amongst groups and identify six groups of intervention, the differences between these individual modality elements were unclear. It was, therefore, not possible to identify one mode of delivery that was more effective than any other.

All interventions seemed to have some impact on the learning and behaviour of participants, assessed six months postintervention, which suggests that any active, multicomponent educational intervention aiming to increase hand hygiene compliance has an impact on recipients' attitudes and/or behaviours. Equally, all studies within reported some degree of statistically significant change for both patient outcomes, change in healthcare professionals' behaviour or both. However, most interventions contained more than one component, thus making the effects of individual features of the interventions difficult to isolate.

Generally, postintervention, infection rates dropped and compliance rates improved. This relationship remained consistent regardless of mode of educational intervention delivery. Rates of compliance with hand hygiene practices postintervention was reported to be between 60% and 70% for most studies. However, there was a large range of compliance rates

Table 5. Summary of outcomes.

Educational intervention type	Kirkpatrick level	Outcome measures used	Number of studies reporting statistically significant results	Statistical significance value range	Other findings
1. Education, multimodal with demonstration	3	Compliance with hand hygiene policy	4/4	0.001 to 0.05	In one study compliance rates increased for nursing staff but decreased for doctors and auxiliary nursing staff.
	4	Change in MRSA rates. Change in catheter-related bloodstream infection rates	3/3	0.001 to 0.05	
2. Education, multimodal without demonstration	3	Compliance with hand hygiene policy	10/12	0.0001 to 0.05	No improvement in hand hygiene compliance in two studies
	4	Reduction in MRSA rate. Reduction in nosocomial infection rates. Reduction in central venous catheter bloodstream infection (CVC-BSI) rates.	7/10	0.001 to 0.94	Reduction in central venous catheter bloodstream infection (CVC-BSI) rates decreased but only in one of the units in the study. One study showed an increase in nosocomial infection rates.
3. Education, multimodal, with self-study	3	Compliance with hand hygiene policy.	4/4	0.0001 to 0.002	There was no significant finding in two of the hospitals monitored in one of the studies.
	4	Reduction in antimicrobial resistant hospital acquired bacteraemia. Decreased rate of nosocomial infection.	3/3	0.0002 to 0.03	
4. Education, multimodal with video	3	Compliance with hand hygiene policy.	1/3	Not specified	
	4	Risk of death per 1000 ICU admissions. CVC-BSI rate.	3/3	0.001	
5. Multimodal education with demonstration and video	3	Compliance with hand hygiene policy	1/1	>0.001	
	4	Decrease in MRSA rates post intervention.	1/1	0.035	
6. Multimodal education with an online element	3	Compliance with hand hygiene policy.	1/1	>0.001	
	4	Decrease in clinical MRSA rates post intervention.	1/1	0.001	MRSA rates remained static 12 months post intervention.

preintervention, with a rate as low as 4.5% being reported (Danchaivijitr et al. 2005). It is possible that hand washing compliance rates which are low have more scope or chance of significant improvement. However, there seems to be a ceiling effect after which improvement in compliance becomes more difficult.

The key to successful intervention is building on these improvements to push compliance rates higher, particularly when initial compliance is reasonably high in the first place. One way of doing this may be by academic detailing (dissemination of information through peers of higher management), which has been shown to have an effect on improving practice (Larson et al. 2000). In most studies compliance rates were generally similar across professional groups. However, one study (Muto et al. 2000) concluded that physician compliance rose significantly when following the attending physician on ward rounds, and in another by Buffet-Bataillon (2010) multivariate analyses suggested hand hygiene compliance was related to job seniority, and suggested that senior healthcare workers could act as role models for junior healthcare workers to boost compliance. It could equally be argued that for compliance rates to improve further, hand washing practices must become intrinsic within professional practice and implemented within teams rather than from external sources.

Often, there were other facets in addition to education that are operating to increase the effectiveness of an intervention, such as informal feedback, reminders and promotion through buttons or stickers. Fox et al. (1989) stated learning occurs through a series of 'impactors', thus multiple-approach interventions are generally deemed to be most effective in changing behaviour. In the studies included in this review, often, external infection control teams delivered the educational interventions. Furthermore, there were other interactions in addition to education that were operating to increase the effectiveness of an intervention. These were reminders in the form of both formal reminders such as posters, feedback,

surveillance, incentives and checklists, and informal reminders, such as informal surveillance or skills testing. Whilst other systematic reviews have considered the effects of reminders as an isolated intervention (Shojania et al. 2009) and deemed reminders to be effective means of behavioural change, for the purpose of this review, only structured educational interventions were considered, thus reminders alone were not sufficient to comprise an educational intervention. It is therefore not possible to draw conclusions as to the usefulness of reminders as a standalone intervention.

Formal educational meetings, with and without demonstration, formed large parts of seven interventions studied in this review. However, they are rarely used as single interventions. Nor are audit and feedback, which have been shown to produce statistically significant increases in behaviour when combined with educational meetings or material (Hulscher et al. 2001). It has been difficult, in this review, to identify the most effective part of the intervention; yet effective bundles of interventions have been identified as part of this review. This supports the work of Peloso (Peloso & Stakiw 2000) and lends support to the conclusion that multiple interventions are more useful in terms of eliciting and sustaining behavioural change than single interventions (Grilli & Lomas 1994; Davis et al. 1995; Oxman et al. 1995).

Only studies that considered a follow-up period of longer than six months were included in this review, as interventions must be shown to be effective in long-term practice rather than in the few months following an intervention (which may be attributable to a Hawthorne-like effect immediately following an intervention). Several studies found this 'wash-out' effect with healthcare professionals' hand hygiene compliance declining to baseline levels postintervention. Repetition of educational interventions every six months was recommended (Helder et al. 2010) in order to maintain high compliance rates with hand hygiene. This was further supported; compliance with hand hygiene was found to increase only marginally on long-term follow-up with no continuous interventions (Dierssen-Sotos et al. 2010). Support for the concept of continuous interventions was also reported by Lobo et al. (2010), who randomised healthcare professionals to receive either continuous education or a single lecture intervention. Continuous education was found to reduce infections rates after 9 months, whereas no reduction was found in the single intervention comparison group (Lobo et al. 2010).

Feedback was an intrinsic and important component of nine interventions. Feedback can take place in several different forms such as the use of UV lamp technology and continuous updates on outcome results. Several studies (Conrad et al. 2010; Dierssen-Sotos et al. 2010; Helder et al. 2010; Helms et al. 2010) made use of UV lamp technology as part of an educational intervention in order to provide performance feedback to the healthcare professionals. This intervention, although in itself mainly assesses the ability and therefore competence of hand washing is another form of education that demonstrates practically to healthcare professionals the importance of complying to hand hygiene guidelines. It also is likely to make the education more memorable as there is interaction involved. Feedback, in the form of monthly study results, has been found to be effective at increasing compliance with hand hygiene (Lobo et al. 2010) and reducing infection (Zhang et al. 2010), and the effectiveness of multifaceted approaches combined with continuous feedback have been recognised (Naikoba & Hayward, 2001). All studies that included the addition of feedback (Lobo et al. 2010; Zhang et al. 2010; Doron et al., 2011) regarded feedback to healthcare professionals an important and effective measure to improve both healthcare professionals' behaviour and patient outcomes. However, from this review it is not possible from the studies in the review to conclude the nature, place or time of booster sessions with feedback in improving the effectiveness of interventions. However, these finding lend support to the notion that interventions consisting of multiple components seem to have the most prolonged effect, and that repeated sessions, fed into daily practice, also improve practice (Cherry et al. 2010) (supporting the work of Fox; Fox et al. 1989).

Only one study (Doron et al. 2011) considered the attitudes and personal values of the healthcare professionals as a basis for the development of the intervention, a factor indicated as prerequisite for some interventions to be successful (Grol et al. 1998; Burgers et al. 2003). This study increased compliance rates from 90% to 96%, possibly helped by this consideration of the ward culture before implementation of the intervention, a suggestion laid out by the World Health Organisation in their guidelines for improving hand hygiene compliance (World Health Organization 2009).

It would be good to put your conclusions in this study and to relate these to the title and review aim of finding out what are the individual features of effective educational interventions that impact on hand hygiene compliance.

Limitations of analysis

The research team accept that it was not possible to separate competence acquisition from compliance when assessing the impact of the included papers. Most papers retaught correct methods of handwashing (competence) and then assessed compliance with this behaviour, thus assessing both competence and compliance simultaneously. Compliance is a broad term that implies whether individuals complete an action they know should be undertaken. However, for the purpose of this review, the research team sought to identify articles reporting compliance as a primary outcome measure and data have been presented accordingly.

Measures were taken to report the methodological quality of each included study. However, despite this strategy, the scoring of items as 'not reported' rather than 'not present' may still have lead to an under-reporting of degree of bias, and consistent variations in reporting may have prevented firm comparisons and made the drawing of conclusions difficult. In addition, outcomes of included studies were reported using Kirkpatrick's hierarchy (Kirkpatrick 1967). The research team acknowledge that other models may also be suitable to categorise the outcomes of reviews such as this.

No study assessed the motivation of healthcare professionals to change as a contributing factor to the success of educational interventions, regardless of mode of delivery. It has been hypothesised that motivation alone may have a

substantial effect on the success of educational interventions when the topic is of low interest to healthcare professionals (Foy et al. 2002). Differences in motivation between participants may affect the reported results, although this will be difficult to identify. This should be taken into consideration, both when generalising the results from this review and planning future research.

Conclusions

It was not possible to identify the individual features of educational interventions that impacted on hand hygiene compliance in healthcare professionals within a hospital care setting due to each study reporting multicomponent interventions. However, several conclusions were drawn. Educational interventions had a greater impact if compliance to hand hygiene compliance best practice was low. Multiple interventions were better than single interventions in terms of eliciting and sustaining behaviour change. Continuous interventions had more of an impact than single interventions in sustaining behaviour change. However, it was uncertain as to how long a change in behaviour would persist after an educational intervention and data were not available to determine the time, nature and type of booster sessions with feedback needed for a permanent change in hand hygiene compliance.

Implications for practice

Following this systematic review, several implications for practice can be suggested.

(1) Taking part in any structured educational intervention designed to improve hand hygiene compliance in a hospital environment is likely to be effective in improving practice.
(2) Combining an educational intervention with other components (reminders, incentives, checklists, surveillance, audit and feedback) is the most effective way of reinforcing the educational message.
(3) Repeated sessions feed into daily practice will maintain compliance.
(4) The first step to improving hand hygiene compliance should be to target educational interventions in areas where compliance to best-practice is poorest.
(5) Consider using performance feedback when educating healthcare professionals. Performance feedback in the form of performance reports or the use of UV technology is likely to increase hand hygiene compliance.
(6) Ensure that hand washing practices become intrinsic within professional practice by using internal teams to deliver interventions rather than external sources.

Implications for research

To inform future reviews to investigate and clarify factors relating to the effectiveness of delivery of education within healthcare, several implications for research must be taken from these findings. Future research could focus on directly assessing trainee engagement in deliberate hand hygiene behaviours, the lasting effects of this on the impact of the educational intervention with regards to hand hygiene compliance. Research should also focus on strategies to embed educational practice within the workplace, and the time, type and nature of booster sessions to maximise educational effectiveness.

With respect to educational interventions, group sizes need to be large enough to measure the relatively small effects of each educational component with adequate specificity and accuracy. Sensitive, generalisable and validated measures are needed to allow for adequate determination of baseline knowledge, attitudes, motivation and behaviour of healthcare professionals regarding hand hygiene practices and for comparisons postintervention. Before and after measurements of hand hygiene compliance are required, with sufficient follow-up periods to ensure longitudinal stability in results. More within-study comparisons of conflicting modes of educational delivery are also needed in future research.

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