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Public perception and the social and microbiological significance of uniforms in the prevention and control of healthcare-associated infections: an evidence review

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Abstract

Background: There is significant public concern in England about health carers wearing uniform in public places and that contaminated uniforms may contribute to the spread of healthcare-associated infections (HCAI). Evidence of a link between contaminated uniforms and HCAI, or that wearing uniforms in public spaces may contribute to the spread of infection from the healthcare environment to the wider community, has not previously been systematically assessed.

Methods: A comprehensive review was conducted that focused on patient perceptions of the significance and infection risks of uniforms and microbiological and clinical evidence of the infection risks to patients from contaminated uniforms.

Results: Uniforms play an important role in the public's perception of healthcare professionals. This is constructed from social and cultural images leading patients to judge the professionalism and trustworthiness of practitioners based on the clothes they wear. The colour and design of uniforms may reinforce socially constructed concepts of cleanliness that result in unachievable expectations. Evidence directly related to the laundering of uniforms is limited. Small scale studies show that uniforms and white coats become progressively contaminated during clinical care and most microbial contamination originates from the wearer of the uniform. Although some studies theorise that uniforms may transmit HCAI, no studies demonstrated this in practice. A small number of studies evaluated the phases of the wash cycle in hospital laundries for patient linen but not uniforms. They indicate that micro-organisms are removed and killed during laundering, and dilution during washing and rinsing is important. Significant reductions in micro-organisms occur at lower temperatures more commonly used in home laundering. A small number of studies show that home laundering provides effective decontamination. We found no recent studies that accounted for advances in domestic washing machine and detergent technology or that addressed the theoretical infection risk linked with wearing uniforms in public places.

Conclusion: Despite the limited amount and quality of the evidence, the general public's perception is that uniforms pose an infection risk when worn inside and outside clinical settings. This is reinforced by media comment and a lack of clear, accessible information and may have a damaging effect on the relationship between professionals and patients and the public image of healthcare workers. There is no good evidence to suggest uniforms are a significant risk, that home laundering is inferior to commercial processing of uniforms or that it presents a hazard in terms of cross-contamination of other items in the wash-load with hospital pathogens. It is essential that the evidence is considered in a balanced way and not over-emphasised in the development of uniform policy and that the general principles of infection control are stressed.

Introduction

The possibility that contaminated uniforms and clothing of healthcare practitioners might contribute to the spread of healthcare-associated infections (HCAI) has become the focus of public anxiety, professional concern and media interest. However, the evidence for making an explicit link between contaminated uniforms and HCAI, or the spread of infection from the healthcare environment to the wider community through the wearing of uniforms in public spaces and home laundering, has not been systematically identified and examined and its relevance to modern healthcare practice assessed. The Department of Health (England) funded the Richard Wells Research Centre at Thames Valley University to undertake a comprehensive review of scientific and social science literature to inform the *Towards cleaner hospitals: lowering rates of infection* programme of work for the Chief Nursing Officer (Jones, 2004).

This article provides an overview of the methods used in the review and summarises the full report. It focuses on the importance of uniforms in framing patient and public perceptions of healthcare professionals and the quality of the microbiological and clinical evidence linking uniforms and other clothing worn during health care with the potential transmission of pathogenic micro-organisms from healthcare staff to patients.

Review methods

Evidence was identified from a systematic search of electronic databases of national and international guidance, published scientific and social science literature. The processes used in the review are shown in Box 1. Due to the limited resources available for this review, studies were not double-blind appraised. However, all studies were appraised and data extracted by one experienced reviewer and then checked by a second experienced reviewer. Evidence tables were constructed for the microbiological evidence and the studies summarised in the narrative synthesis. Studies relating to public perceptions were appraised and the evidence presented in a thematic narrative.

Issues of public perception and professional image

A uniform contributes to the image projected by a profession or organisation and is generally recognised by the general public. Craik (2005) suggests that uniforms also serve other purposes that have a social and psychological impact on the wearer and society as a whole. Joseph (1986) states that "The uniform serves several functions: it acts as a totem, reveals and conceals status, certifies legitimacy and suppresses individuality." This sense of image and belonging has intrinsic value to individuals and institutions and extrinsic importance to the wider public. A feature of the literature surrounding nurses' and doctors' uniforms is the importance attached to enabling patients and staff to easily recognise the role, experience and seniority of an individual practitioner often indicated by particular colours and accessories, many of which have historical associations (Dolan, 1973; Blumhagen, 1979; Tiffany and Sparrow, 1987; Davies, 1995). However, some writers indicate that uniforms also lead to stereotyping of groups. Nurses in uniform are often depicted as angels of mercy, sex symbols or battleaxes in the media and popular culture while doctors are depicted as philanderers or omnipotent (Dolan, 1973; Szasz, 1982; Tiffany and Sparrow, 1987; Craik, 2005).

There are differing perspectives on the significance of uniforms in conveying identity and their importance to both patients and staff. The professionalisation of nursing and midwifery, the feminist movement of the 1960s and the increasing number of men entering nursing and midwifery challenged the traditional handmaiden role and the imposition of outdated dress codes (Campbell et al, 2000; Kalisch and Kalisch, 1985). During the 1980s the prevailing professional view was that wearing a uniform resulted in nurses and midwives being bound to outdated handmaiden roles with little professional identity (Flint, 1984; MacFarlane, 1990; Pearson et al, 2001) and that the exclusivity and identity associated with nurses' uniforms was diminishing. A wide range of healthcare workers wear a uniform dress and the white coat is worn by many allied health professionals, clinical support staff, ward administrators and nurses in non-clinical roles. In addition, the choice not to wear a uniform or white coat is viewed as an indicator of professional seniority and autonomy in both medicine and nursing (Buckingham and McGrath, 1983).

Observational research and anecdotal literature points to the fact that the general public associate nurses and doctors in particular with specific items of uniform and that they hold views about the purpose of uniforms (Dunn, 1987; Sparrow et al, 1991; Campbell et al, 2000; Gooden et al, 2001; Harnett, 2001; Tiwari et al, 2001). In a study that addressed the issue of "what kind of nurses do patients want?", patients were shown four photographs of nurses and asked which of the four they would prefer to care for them and if they would prefer not to be cared for by any of the four (Webb and Hope, 1995). All the photographs were of young, white females, in plain white nurses' uniform with hair of differing lengths from short to long and styles including loose shoulder length hair, a pleat and plaits. The nurse with plaits also wore a nose stud. In interviews 50.5% of the patients preferred to be cared for by the nurse with short hair. Thirty five per cent of patients said that they would prefer not to be cared for by the nurse wearing plaits and a nose stud. Reasons for making these choices were associated with the way in which patients attributed particular qualities to the preferred nurse in

Box 1. Summary of review methods

Review questions

What is the evidence that:

1. Uniforms play an important role in maintaining public confidence and trust in healthcare?
2. Uniforms are a potential source of nosocomial infection?
3. There is an epidemiological link between microbiological contaminants found on uniforms and cases of healthcare associated infection?
4. Some parts of the laundry cycle are more effective than others at reducing soil?
5. There is a difference in decontamination efficacy between domestic and industrial processes for laundering of uniform?

Medline search strategy

CLOTHING/; TEXTILES/; DETERGENTS/; SOAPS/; Household Products/; Disinfection/; Disinfectants/; decontamination/; Hygiene/ or Housekeeping Hospital/; Heat/; Cell Survival/; Water Microbiology/; LAUNDERING/; Hygiene/Laundry Service, Hospital/; BACTERIA/; VIRUSES/; Infection Control/Cross Infection/; Communicable Disease Control

Databases searched

- The National Research Register
- MEDLINE; EMBASE; CINAHL;
- Cochrane Clinical Trials Register;
- CRD and DARE; and
- HEMIC.

Study inclusion criteria

1. The intervention/investigation is clearly described and applicable to current practice or patient perception.
2. The microbiological techniques are applicable to current practice, standard, valid and reliable.
3. The study outcomes are measured in a standard, valid and reliable way or described in a way that is credible, transferable and dependable.

Quality assessment and data extraction

Data extraction was conducted using the Scottish Intercollegiate Guideline Network 2001 for study quality assessment tools.

1. All studies were appraised and data extracted by one experienced reviewer and then checked by a second experienced reviewer.
2. Evidence tables were constructed from the quality assessments.
3. Due to the heterogeneity of design and outcome measures the studies were synthesised in a narrative report.

terms of kindness and ability to sympathise and the disliked nurse as looking stern.

In a paediatric setting where a move to non-uniform wearing was being considered, investigators first conducted in-depth interviews to elicit the views of parents, children and staff about nurses' uniform

(Campbell et al, 2000). The issues that were important to families were that they should be able to differentiate between clinical staff and other people and that they should also be able to identify different grades of staff from their uniform, particularly the sister in charge. They also indicated that they wanted the uniform to communicate the "atmosphere" of the ward and the attributes that the nurses were expected to display. Opinion was divided between an atmosphere that was "clinical, authoritative and confident" or "relaxed and approachable". The third category identified during the interviews was focused on communication and the perceived "formality or friendliness of the nurse in the uniform".

The second phase of this study was a questionnaire survey with nine items derived from the interview phase. The questionnaire was distributed to 500 families and 430 were returned (80% response rate). The responses strongly supported the notion that the uniform worn by nurses needed to be identifiable (95%), distinguishable from parents and other groups of staff (67%) and that the sister in charge needed to be recognisable (60%). Ninety per cent of the respondents said that they wanted the clothing that nurses wore to present a friendly and relaxed ward atmosphere, and 93% agreed that they wanted clothing to make nurses seem friendly. However, a subsequent item asked families if they thought that the clothes nurses wear should represent an authority figure and 39% agreed or strongly agreed with the statement. It was also clear that this sample of families did not feel that "casual" dress led to them feeling less secure. When asked to choose between a uniform that included a polo shirt and a traditional uniform, 57% preferred the polo shirt but 32% preferred the old style uniform. On the basis of these results the nurses in this unit changed to a uniform that included different coloured polo shirts for different grades of nursing staff. The findings of this study are mirrored by the results of another study which identified that children find uniforms, and white coats in particular, frightening (Marino et al, 1991). However, another study focusing on identifying how children perceived nurses' uniforms suggested that the familiar nurses' dress caused less anxiety because it met the child's expectations of what a nurse would look like (Livingston, 1995).

A questionnaire study conducted by Tham and Ford (1995) in four acute psychiatric wards in London hospitals investigated patients' attitudes to physicians' dress and asked patients, nursing and medical staff about three issues – the importance of staff dress, the preferred mode of staff dress and the identification of staff. Both doctors and nurses indicated that they had experienced difficulty in differentiating staff from patients, but only 38% of patients found this to be the case. More than 90% of doctors said that they had difficulty in knowing how senior a member of staff was, whereas nurses (55%) and patients (45%) found this less difficult. Seventy seven per cent of respondents felt that staff should wear name badges. Interestingly, 62% of doctors, 52% of nurses and 64% of patients did not feel that formal dress made staff less approachable. This study concluded that patients were more tolerant than physicians about informal attire.

Two studies conducted in nursing development units, one in Australia (Pearson et al, 2001) and the second in the UK (Sparrow, 1991), used qualitative methods to elicit patient and staff opinions of the change from uniforms to non-uniform wear. Due to the qualitative design of the studies the number of informants in each was relatively small (51 patients and 16 staff) in the UK study and 14 nursing staff in the Australian study but both provide an insight into perceptions of patients and staff in those units.

In the UK study (Sparrow, 1991), patients and nurses identified two recurring reasons for wearing uniforms – the first for identification and identity and the second for confidence. The issue of identification was raised as a means of differentiating between nurses and other members of the hospital team and the general public, with some patients finding the lack of uniform confusing, taking "three days to identify who was a nurse." Some nurses on the other hand felt more comfortable in their own clothes and suggested that it made them feel "less anonymous – working as a person". Those nurses who opposed the change indicated that they felt that their identity as

a nurse was threatened. Patients also indicated that a uniform gave them confidence in the nursing staff and reduced their fear and anxiety. However, the investigators highlight that patients did not differentiate between the levels of experience of nurses in uniform and saw all those wearing a uniform, including student nurses, as knowledgeable and trustworthy. Those nurses who preferred to wear uniform felt that it helped to instil confidence in patients as well as the nurse. In comparison, those nurses who preferred non-uniform stated that they felt "more confident out of uniform as people were forced to recognise me and value me for what I could offer". Before the change to non-uniform wear was made patients thought that it would not make a difference to the way they perceived nurses, with 12% stating that they supported or felt neutral (47%) about the change. Following the change, 66% of patients interviewed stated that they would prefer nurses to wear uniform.

In the Australian study (Pearson et al, 2001) focus groups indicated a balance between traditionalists and those who perceived the change to non-uniform as professionally empowering. Many of the responses supported some of the issues already discussed, such as the need to be identifiable and the legitimacy bestowed upon the individual by wearing a uniform. Uniform was also seen as a protective shield that helped them to undertake difficult aspects of care and separate home from their workday. The investigators concluded that uniform still played a large part in shaping the identity of nursing in acute care and that nurses were reluctant to abandon it. This study did not investigate the opinions of patients.

We identified five studies that investigated perceptions of medical staff dress from both the patient and clinician perspective. In a study conducted in Israel by DeKeyser et al (2003), 77% of patients felt that staff, including doctors, should wear a uniform, with 56% stating that uniforms helped to identify staff roles. An Australian study of 337 junior hospital medical officers (JMO) identified their attitudes to wearing white coats as part of a national survey of JMO-preferred sources of information (Ashley et al, 2002). Respondents indicated that 98% of their JMO colleagues did not wear white coats. When asked what purpose white coats had if they were worn, 84% of respondents indicated that they were useful for carrying pocket books and other equipment, 55% felt that they would look more professional and 53% identified that a white coat might help to protect their clothing. Forty five per cent of JMO felt that a white coat helped to identify them as medical staff.

A further study conducted in a Birmingham Children's Hospital out-patient department presented parents and children with five photographs of medical staff dressed formally and informally and asked them to assign positive and negative attributes to the wearers (Barrett and Booth, 1994). This study found that 70% of parents and children thought that how doctors dressed was important. Children assigned greater "skill" to the male and female doctors wearing a white coat (44%), but felt that they were less friendly than those who wore polo shirts. Those from an Asian background or attending surgical appointments preferred doctors in white coats. In general, parents favoured a more relaxed dress code, but expressed their preferences less strongly. Parents also failed to predict how their children might feel about the different doctors.

Douse et al (2004) report results from a similar study in the UK that indicated 56% of patients favoured doctors wearing white coats. Significantly more patients over the age of 70 thought that their doctors should wear white coats. The primary reason given by patients who wanted doctors to wear white coats was for ease of identification (31%) and looking more professional (7%). In comparison, only 24% of doctors felt that they needed to wear white coats. Their primary reason for not wearing coats was their perception that white coats contributed to healthcare associated infection (70%).

In general these studies show a mixed set of perceptions of both patients and staff to the wearing of uniform. The number of respondents in all studies was limited and therefore it is not possible to draw firm conclusions. However, these studies suggest that patients would prefer staff to wear a uniform of some kind that helps them to identify

the different groups of staff involved in their care. Interestingly, a recent study suggested that modern matrons, who hold an influential and pivotal role in ensuring the quality of the patient environment, are unrecognised by patients because they are less visible and identifiable (Bufton, 2005). The preference for traditional uniforms or less formal clothing is less well defined and may depend on several factors, such as age, cultural perceptions and clinical setting or speciality. It also emerges that patients feel more secure and confident in their care when staff wear a uniform. However, in some authors opinions (Sparrow, 1991; Campbell et al, 2000; Pearson et al, 2001) this confidence may be based on traditional stereotypes, social expectations and previous experience rather than an accurate assessment of the experience or skill of the nurse or doctor and in some cases may be misplaced if a uniform is the only identifier used by patients.

The relationship between public trust and uniforms is derived from the legitimacy that a uniform signifies to the outside world. It has been suggested that, "Uniforms are extremely effective indicators of the codification of appropriate rules of conduct and their internalisation" but that it is the underlying rules that are more important than the uniform itself (Craik, 2005). A uniform enables the group to carry out the legitimate activities associated with the occupation. In healthcare professions this legitimacy makes it acceptable for the wearer to approach patients and invade their physical and psychological space and signifies knowledge and expertise that has been gained through formal education and training. Any abuse of the authority invested in practitioners or behaving in a manner that does not fit with society's expectations of the person wearing the uniform may lead to a reduction in patient confidence and trust (Castledine, 2004). The current wave of public opinion and dissatisfaction associated with healthcare staff wearing their uniforms outside the clinical setting and public places is an example of what the public consider to be unacceptable behaviour and undermines patient confidence in those delivering patient care.

Uniforms as a social and physical barrier

The issue of uniform as a barrier is derived from two assertions. The first is related to the social barrier created between patient and health carer at an interpersonal and therapeutic level and the second is the perception that uniforms act as a physical barrier that protects patients and healthcare workers from infection.

Some authors refer to uniforms as a power symbol (Casey, 1988; Pearson et al, 2001) that serves to constrain and proscribe the relationships between patients and healthcare professionals. As well as reminding professionals of their place in the hierarchy, uniforms serve as a reminder to patients and relatives that the professional has knowledge and authority that affects their lives. This attitude is the antithesis of the modern approach to health care as a partnership between patients and professionals (Pearson and Vaughan, 1986). In clinical specialities, such as primary care, psychiatry, child health and midwifery, there has been a move away from wearing traditional uniform in order to enhance the therapeutic relationship and remove the perceived power relationships between patients and professionals (Rowland, 1994; Brennan et al, 1995). Some small scale observational studies suggest that patients are more likely to be active in their own care, seek information and question decisions when the "experts" are dressed in everyday clothing (Hawkey and Clarke, 1990; Sparrow, 1991; Tham and Ford, 1995). However, much of the literature addressing this issue is based on assumption. There is little work that tests the hypothesis that non-uniformed professionals are more approachable and that this has a positive effect on patient outcomes. It is possible that the interpersonal skills of the professional are the key to therapeutic relationships rather than the abandonment of traditional modes of dress.

In the move away from wearing uniforms in some areas of health care, the assertion that uniforms are part of infection control measures and offer physical protection from infection may be given to resist change. The use of white for coats, dresses and tunics presents an image of cleanliness that until recently led patients to think of

uniforms, particularly the doctors' white coat, as having some magical quality that keeps them clean and free from contamination (Blumhagen, 1979; Craik, 2005). In some observational studies patients state a preference for uniforms because they perceive them to be cleaner than everyday clothing (Sparrow, 1991; Campbell et al, 2000; Gooden et al, 2001). In one study conducted in a UK nursing development unit, a reason that nurses gave for continuing to wear uniform was that nursing involved "dirty work" that would soil their own clothing (Sparrow, 1991). Nursing staff who perceived themselves as having a greater awareness of the need for cleanliness, reported wearing plastic aprons for protection more frequently and washing their hands more often than other staff. However, the non-participant observation periods, although not extensive or focused on this issue, did not support this perception. In another study in a non-uniform wearing ward no significant difference was found between the microbial contamination of uniforms and non-uniform clothing (Hawkey and Clarke, 1990).

The gap between scientific evidence and patient perception

The perceived link between contaminated uniforms and healthcare associated infection has two core elements: the extent to which uniforms become contaminated with hospital pathogens and whether any potential pathogenic micro-organisms on uniforms are transmitted to patients during care activities and cause HCAI. Our review identified six small scale studies for appraisal, four of which focused on nurses' uniforms (Speers et al, 1969; Babb et al, 1983; Callaghan, 1998; Perry et al, 2001) and two studies that investigated contamination of white coats (Wong et al, 1991; Loh et al, 2000). The quality of these studies is summarised in Evidence Table 1. The studies demonstrate that uniforms and white coats become progressively contaminated during clinical care and that contamination reaches a level of saturation that then plateaus. The time taken to reach this level of saturation is unclear and is likely to depend upon the amount of patient microbial colonisation, frequency and types of clinical activity and other factors, such as the level of environmental microbial contamination and the extent and effective use of protective clothing. Studies concluding that uniforms become contaminated during a shift or episode of care hypothesise that those uniforms are a potential vehicle for the transmission of micro-organisms which may cause HCAI. However, none of these studies demonstrates the transfer of micro-organisms from uniforms to patients. It is worth highlighting that even clean uniforms will quickly become contaminated by skin commensals acquired from the wearer's skin, and additional microbial contamination from the environment is also inevitable. The study conducted in an isolation unit (Babb et al, 1983) highlights that where protective clothing, such as aprons, is used for direct contact with patients, exogenous contamination of uniforms from patients or their environment can be minimised.

There were no studies that showed an epidemiological link between uniforms worn in practice and cases of HCAI. Although one study demonstrates a link between scrub suits and surgical site infection this was in specific and unusual circumstances involving clothing that was supplied highly contaminated rather than being contaminated during use (Barrie et al, 1994). One further study demonstrates a theoretical possibility that clothing can transmit micro-organisms to the patient or their environment but does not prove an epidemiological link with infection (Hambraeus, 1973). This study also highlights the important relationship between the potential contamination of uniforms and the use of protective clothing.

These studies generally point to the conclusion that traditional uniforms and other clothing worn for patient care should be viewed as work attire and not as patient or personal protective clothing. Evidence from other studies has shown that cotton gowns are a less effective barrier than plastic aprons, and gowns are therefore no longer used in general clinical practice (Pratt et al, 2007; Pellowe et al, 2003). The use of plastic aprons as a component of standard principles for preventing HCAI minimises the risk of micro-organisms being transferred from

Evidence Table 1. Uniforms as a means of transmission and cause of healthcare associated infections (HCAI)

Author, date, title and objective	Design, setting and sample size	Authors' conclusions	Comments on quality and applicability
<p>Hambreus A, 1973. Transfer of <i>Staphylococcus aureus</i> via nurses' uniforms. To study the importance of transfer of <i>S. aureus</i> by means of nurses' clothing in a burns unit.</p>	<p>Experimental burns unit. 57 sets of uniforms and cover gowns worn by nursing staff during: – normal work – standardised exercise – simulated nursing activity using a healthy volunteer. Samples were collected from uniform and cover gowns using a "wash method" following comparative test with other methods. Process for estimating the transfer of <i>S. aureus</i> from gown to uniform involved a nursing procedure being carried out in a clean uniform and gown. The uniform and gown were then placed in a plastic bag prior to sampling. Transfer from one patient to another was demonstrated as follows: uniforms and gowns were used for a real nursing procedure and then taken off and worn by a laboratory worker, who then conducted a 25 minute nursing activity with a healthy volunteer. The patient's gown and sheet from the bed were sampled.</p>	<p>It was shown that both protective gowns and uniform jackets worn underneath became heavily contaminated during the nursing of a burned patient. When worn over contaminated uniforms, gowns appear to have little effect in reducing the dispersal of contaminating organisms into the receiving room. Besides the presence of airborne staphylococci dispersed from clothing, in 12 of 15 experiments, it was possible to isolate staphylococci derived from a burned patient on the protective gown and bottom sheet of the model patient. The maximum value found was 3×10^3 CFU. In three experiments there was no evidence of transfer.</p>	<p>Complex experimental study within a specialised care environment. Burns patients are generally heavy dispersers. Variables controlled and a simulated approach taken to demonstrate transfer of organisms from one patient to another.</p>
<p>Loh W, Ng VV, Holton J, 2000. Bacterial flora on the white coats of medical students. To determine the level and type of bacterial contamination present on the white coats of medical students in order to assess the risk of the spread of nosocomial infections by such contact in a hospital setting.</p>	<p>Survey and bacterial sampling. Urban medical school based in three general hospitals. 100 medical students. Students selected at random and a bacterial sample collected from three sites on each coat (cuff and side pocket of dominant hand and centre back) over a period of four weeks.</p>	<p>Data suggests that coats become contaminated quickly once worn and there is little difference between colony counts and frequency of laundering. These results suggest that healthcare personnel should remove their white coats when examining patients. Bacterial contamination carried by the coats supports the ban on the wearing of these coats in non-clinical areas.</p>	<p>Observational data with no statistical measures of significance. Contamination may have originated from wearer.</p>
<p>Speers R, Shooter RA, Gaya H, Patel N, 1969. Contamination of nurses uniforms with <i>Staphylococcus aureus</i>. An investigation of the presence of <i>Staphylococcus aureus</i> on nurses' uniforms and the sources from which they become contaminated.</p>	<p>Microbiological sampling survey; general medical and surgical wards. Three different surveys were conducted in a general surgical ward (12 female nurses), seven randomly selected wards in the same hospital (56 nurses) and a surgical ward in another hospital (15 female nurses, four male nurses and two male doctors). Uniforms were sampled at the beginning and towards the end of a shift using a sweep plate method that would resemble the contact that would occur in clinical activity. In experiments 1 and 3 nasal swabs were taken for phage typing.</p>	<p>Contamination of clothing is another way in which staphylococci might be spread in hospitals, but its importance is difficult to assess. If infection control precautions are followed, contamination from clothing may not add greatly to the risks of infection to which patients are exposed as <i>S. aureus</i> is isolated from the patients themselves, their bedding and other aspects of the environment. There is little justification for the use of conventional aprons, alternatively plastic aprons should be worn. Money might be better spent on a clean uniform every day.</p>	<p>Sweep plate method easily applicable but probably of low efficiency and reproducibility. Sound design and methods which attempts to take account of confounding variables.</p>

Continued

Evidence Table 1. Continued

Author, date, title and objective	Design, setting and sample size	Authors' conclusions	Comments on quality and applicability
<p>Wong D, Hollis P, Nye P. 1991. Microbial flora on doctors' white coats.</p> <p>To determine the level and type of microbial contamination present on the white coats of doctors in order to assess the risk of transmission of pathogenic micro-organisms by this route in a hospital setting.</p>	<p>Cross sectional survey. Urban general hospital. 100 doctors surveyed and samples taken from the cuff, lower front pocket and back of the white coat using contact plates. Plates were incubated at 37°C for 18 hours. Nasal swabs were taken from participants if <i>S. aureus</i> had been isolated from their coats.</p>	<p>A steady state of maximal contamination is achieved within the first week of use and does not change significantly after this. There is little microbiological reason for recommending a more frequent change of coat than weekly. The cuffs of coats are more likely to come into contact with patients during clinical examinations and therefore close fitting cuffs or removal of white coats and wearing of plastic aprons when examining wounds is recommended.</p>	<p>Observational study with some statistical measures of association. Variables associated with staff carriage are taken into account.</p>
<p>Callaghan I, 1998. Bacterial contamination of nurses' uniforms: a study.</p> <p>To examine levels of contamination on nurses' uniforms and the role, if any, of plastic aprons in reducing these levels.</p>	<p>Quasi-experimental with additional survey. Renal dialysis and haematology ward in a district general hospital. Pilot phase – 48 uniforms. Experimental phase - 40 uniforms. Laundering phase – 15 uniforms contaminated with <i>Serratia marcescens</i>. Survey – 224 nurses working in three different hospitals.</p>	<p>Wearing plastic aprons did not appear to reduce the level of bacterial contamination of uniforms. Uniforms were found to be contaminated at a similar level at all times of the shift. Staff did not wear a clean uniform every day and there were differences in laundering practices. Recommends that uniforms washed at home should be laundered on their own at 60–65°C and ironed with a hot iron when dry. They should be stored in an unused clean plastic bag and sealed for storage.</p>	<p>Small scale study. Confounding variables were poorly controlled and comparative data was absent for some aspects of the study. Contamination was measured by CFU, and organisms were not identified.</p>
<p>Perry C, Marshall R, Jones E, 2001. Bacterial contamination of uniforms.</p> <p>To assess whether meticillin resistant <i>Staphylococcus aureus</i>, <i>Clostridium difficile</i> and vancomycin-resistant enterococci were present on the uniforms of healthcare workers at the beginning and end of a span of duty.</p>	<p>Cross sectional survey with microbiological sampling. Urban general hospital. 57 ward staff. Uniforms were sampled using a Cassella slit sampler.</p>	<p>Uniforms become contaminated during clinical duties. Suggests that the contamination levels of some uniforms prior to duty was the result of inadequate laundering and that contamination levels increase with extended use.</p>	<p>Small scale cross-sectional study. Lack of repeated measures means that some variables are not taken into account. No data collected on laundering.</p>
<p>Babb JR, Davies JG, Ayliffe GAJ, 1983. Contamination of protective clothing and nurses' uniforms in an isolation ward.</p> <p>To determine the presence of <i>Staphylococcus aureus</i> and Gram-negative bacilli on protective clothing and uniforms of staff working in an isolation ward.</p>	<p>Two phase microbiological monitoring study. Isolation ward of a general hospital. Phase 1 – samples taken weekly from cotton gowns, plastic aprons and uniforms of the nurses working on the ward, taken from the front at approximately bed height. Using 25cm² contact plate and at different times of the day. Phase 2 – carried out over 20 week period with a crossover from gowns to plastic aprons after a 10 week period. Protective clothing and nurses' uniforms were sampled on the front at bed height and the shoulder.</p>	<p>Contamination of protective clothing did not increase when used over periods of up to 11 days. Fewer organisms were recovered from the fronts of nurses' uniforms when plastic aprons were used instead of gowns. Gowns provided better shoulder protection. Nurses' uniform dresses showed similar levels of contamination to protective clothing. It seems likely that uniforms, though only worn for a day in this study, would show a plateau of contamination similar to the protective clothing.</p>	<p>Sound observational study. Efforts made to account for variables such as source of isolates.</p>

Continued

Evidence Table 1. Continued

Author, date, title and objective	Design, setting and sample size	Authors' conclusions	Comments on quality and applicability
Boyce JM, Potter-Bynoe G, Chenevert C, King T, 1997. Environmental contamination due to meticillin-resistant <i>Staphylococcus aureus</i> : (MRSA) possible infection control implications. To study the role of contaminated environmental surfaces as reservoir of MRSA in hospitals.	Prospective survey. 200-bed university affiliated hospital. 38 consecutive patients colonised with MRSA – 20 cultures from nurse gowns/uniforms after morning care (patients with MRSA in wounds or urine).	Inanimate surfaces near to patients colonised with MRSA commonly become contaminated. The uniforms of nurses caring for patients with MRSA in wounds/urine commonly become contaminated.	Small sample size and extent of contamination not reported (just + or –). No direct evidence that micro-organisms acquired on uniforms are transferred to other patients.
Barrie D, Wilson JA, Hoffman P, Kramer JM, 1992. <i>Bacillus cereus</i> meningitis in two neurosurgical patients: an investigation into the source of the organism. Case report of the investigation into the source of <i>B. cereus</i> .	Case report. Neurosurgical ward and theatre in large district general hospital. Microbiological samples were taken from: theatre ventilation; hands of healthcare staff; environmental samples from surfaces, floors and equipment in theatre, theatre changing rooms including theatre scrub suits; and wound swabs from 30 patients who had been operated on in the same theatre in the same week as the patients who had developed the wound infections.	In light of the early onset of infection following surgery and heavy contamination of operating theatre clothing the authors concluded that contaminated linen in the operating theatre was the probable source of <i>B. cereus</i> .	<i>B. cereus</i> is not a common organism causing HCAI. However, this case report makes clear links between contaminated theatre scrub suits and infection.

uniform to patient and patient to uniform and is currently recommended in national infection prevention guidelines (Pratt et al, 2007; Pellowe et al, 2003). Uniforms should not be considered as a substitute for protective clothing. Protective clothing that is appropriate for the care activity should be worn for selected patient contacts and discarded immediately after that contact.

International and national guidance on provision and care of uniforms

In the United States of America (USA), employers are required to launder workers' personal protective garments or uniforms that are contaminated with blood or other potentially infectious materials (OSHA, 1991). However, in general staff are responsible for laundering their own uniforms and scrub suits at home. Guidelines for environmental infection control in healthcare facilities issued by the Centers for Disease Prevention and Control in the USA recommend that hospital linen should be washed with detergent in water at 71 °C or more for 25 minutes or the use of a chemical disinfectant at a suitable concentration for wash cycles using temperatures of less than 71 °C. They make no recommendations directly related to uniforms or work clothing (HICPAC, 2003).

Australian infection control guidelines make two references to uniforms. They require uniforms to be clean and in good condition and that facilities for changing and disposal of soiled uniforms should be provided. Laundry practice standards make no specific reference to the requirements for the home laundering of uniforms (Australian Government Department of Health and Ageing, 2004; Standards Australia International and Standards New Zealand, 2000).

In Belgium, employers are required to provide, launder, repair and replace work clothing in healthcare institutions. They are also required to collect and treat work clothing separately from patients' linen, and staff are forbidden to take work clothes home (Consiel Supérieur d'Hygiène, 2005).

The Netherlands is currently drafting guidance on the laundering of uniforms but this is not yet available. In Denmark one of the 12 hygiene

standards relates to the handling and laundering of linen for multiple use (National Audit Office, 2004). This requires hospital linen to be processed in a cycle that includes water at a temperature of 80 °C for at least 10 minutes or the use of a chemical disinfectant which would have an equivalent effect to thermal disinfection. However there is no specific standard for the laundering of uniforms or a requirement for hospitals to provide a laundering service for work clothing.

In the UK current guidance is directed at the processing of used (including fouled, infected and thermolabile) hospital linen (National Health Service Executive, 1995) and contains no specific guidance on the processing of staff uniforms. Guidance on the provision and laundering of work clothes is minimal and the evidence base is often unclear or not cited. That which does exist is related to the risks associated with bloodborne viruses and the proper use of personal protective clothing, the measures that should be taken when exposure to blood or body fluids has occurred (Pratt et al, 2007; Pellowe et al, 2003).

The provision and laundering of uniforms across healthcare institutions and different countries is a mixed picture. In the UK the provision of uniforms within the NHS and the private sector has historically been the responsibility of employers. However, many healthcare staff who are employed through agencies are responsible for purchasing their own uniforms. The role that healthcare staff uniforms might play in the transmission of HCAI has received considerable media coverage following the publication in 2005 of a survey conducted by the Royal College of Nursing (Nye et al, 2005). Uniform policies were made available to the researchers by 18 trusts and responses to the questionnaire items relating to policy indicated that 60% of policies discouraged the wearing of uniform outside the work environment. In addition, 52% of policies contained advice about laundering uniforms at home. However, advice was inconsistent, particularly in relation to wash temperatures. The authors suggest that a combination of insufficient numbers of uniforms, inadequate changing facilities and lack of laundering provision means that staff find it difficult to follow relevant NHS advice and guidance (National Health Service Executive, 1995; NHS Estates, 2003).

In Denmark, Holland and Belgium healthcare institutions are responsible for the provision and laundering of healthcare staff uniforms and staff are generally not allowed to travel in uniform or take uniforms home to launder. In other healthcare economies, such as the USA and Canada, uniforms are rarely provided by healthcare organisations and members of staff are required to purchase and launder their uniforms.

The evidence for commercial versus home laundering

Concern has been expressed that domestic washing machines do not provide a sufficiently controlled environment in which to safely decontaminate staff uniforms. In particular, it has been suggested that if washed with other clothing, cross-contamination with hospital pathogens may occur. The quality of published studies in this field is summarised in Evidence Table 2. Home laundering of uniforms has been investigated, but studies are few, small scale and have method-

ological flaws. That said, they suggest that home laundering of uniforms provides effective decontamination. Current practice and guidance for laundering uniforms are extrapolated from studies of the general principles of the efficiency and reliability of thermal disinfection. There are a small number of studies that have evaluated the different phases of the wash cycle, although they are mostly based in hospital laundries and relate to patient linen rather than uniforms. These studies indicate that micro-organisms are both removed and killed during the laundering process and that dilution during both washing and rinsing is a key factor in removing micro-organisms. Although more micro-organisms may be killed at higher temperatures, significant reductions in micro-organisms also occur at the lower temperatures more commonly used in domestic washing machines, e.g. 40°C. There is no good evidence to suggest home laundering of uniforms is inferior to commercial processing as a means of deconta-

Evidence Table 2. The laundering process as means of eliminating microbial contamination and comparison of uniforms laundered at home and in hospital laundries

Author, date, title and objective	Design, setting and sample size	Authors' conclusions	Comments on quality and applicability
Smith JA, Neil KR, Davidson CG, Davidson RW, 1987. The effect of water temperature on bacterial killing in laundry. To test the feasibility of low temperature washing by investigating the killing action of hot and cold wash formulas.	Experiment. Washer extractor. Three sets of experiments measuring bacteria in effluent water and 20 linen samples passed through each process (high temperature wash; low temperature and bleach wash; flat iron; tumble dry).	Both wash formulas reduced microbial loads in heavily soiled linen by a factor of 4 to 5 Log ₁₀ . Bleach was the most important bactericidal step in low temperature washing (but concentration was not reported). Temperature and alkalinity eliminate bacteria earlier in high temperature washing. Some of the reduction due to the effect of dilution	Measured micro-organism in wash effluent and impression plates of fabrics to evaluate effect of drying. Undertaken in one washer only. Addition of bleach not relevant in domestic setting.
Orr KE, Holliday MG, Jones AL, et al, 2002. Survival of enterococci during hospital laundry processing. To test the efficacy of hospital laundries in removing enterococcus from linen.	Experiment. Nine industrial hospital laundries (no information on machine type). 40 strains at Laundry A. 12 strains at nine laundries (111 tests).	Bacteria resistant to high temperature are eliminated by the standard (Department of Health) recommended washing temperatures and that high log reductions are achieved by washing alone.	Since strips inoculated with test organism were added to a standard load the effect seen could have been due to redistribution of the organism through the load.
Patel SN, Murray-Leonard J, Wilson APR., 2006. Laundering of hospital staff uniforms at home. To evaluate whether staff uniforms can be effectively decontaminated in domestic washing machines.	Experiment. New domestic washing machine. 10 × 5cm squares of scrub suits, inoculated with <i>S. aureus</i> . Six squares of different types of fabric inoculated with <i>S. aureus</i> (processed at 40°C + tumble dried). Four uninoculated squares washed in four different machines at 60°C.	Washing removes heavy contamination of <i>S. aureus</i> , regardless of temperature of the wash or type of fabric All the organisms recovered on the fabrics after washing were derived from the machine not the initial inoculum of <i>S. aureus</i> and were removed by tumble drying and/or ironing. Authors concluded that workers' clothes can be safely washed at 40°C if tumbled dried for 30 mins and ironed.	Use of swatches means that the effect seen could have been due to the high level of dilution in the wash.
Blaser MJ, Smith PF, Cody HJ, et al, 1984. Killing of fabric-associated bacteria in hospital laundry by low-temperature washing. To determine whether washing at 22°C resulted in significantly different bacterial counts to a high temperature wash.	Experiment. Commercial washer-extractor. Micro-organisms enumerated from rinse water in 226 separate runs.	Authors concluded that dilution, bleach and drying had the most impact on eliminating bacteria. As well as reducing bacterial counts the laundering process also shifted the population towards bacteria of low pathogenicity. Low temperature wash was as effective as high temperature washing in eliminating pathogenic bacteria.	Unknown applicability to contemporary domestic washing machines, cycle times unknown but short (30 mins) compared to modern machines.

Continued

Evidence Table 2. Continued

Author, date, title and objective	Design, setting and sample size	Authors' conclusions	Comments on quality and applicability
Christian RR, Manchester JT, Mellor MT, 1983. Bacteriological quality of fabrics washed at lower-than-standard temperatures in a hospital laundry. To determine whether the bacteriological quality of fabric processed in a hospital laundry could be maintained using wash temperatures lower than 75°C.	Experiment. Hospital laundry, washer extractors. 16 wash processes.	Microbiological quality of fabric can be maintained by using wash temperature less than 75°C. The effectiveness of bacterial density reduction at low temperature was augmented by increased concentrations of bleach. Successful low-temperature washing may save both energy and money for hospitals.	Addition of bleach is not used as standard in laundry processes or domestic machines.
Wilcox MH, Jones BL., 1995. Enterococci and hospital laundry. To determine whether enterococci survive the hospital laundry system	Experiment. Continuous batch washer, commercial laundry in a process that included a wash at 65°C for 10 mins. 6 × 6 inoculated swatches.	No enterococcus recovered after processing (only <i>Bacillus spp.</i>)	Enterococcus on swatch likely to be diluted in processing in standard load.
Bradley CR, Fraise AP, 1996. Heat and chemical resistance of enterococci. To evaluate the susceptibility of strains of enterococci to temperature.	Experiment. Laboratory. Eight clinical strains of enterococci.	Some strains resistant to recommended wash temperatures but in practice the combination of cleaning and temperature likely to be effective to prevent cross-infection.	Testing in laboratory rather than laundry conditions.
Walter WG, Schillinger JE, 1975. Bacterial survival in laundered fabrics. To determine the bacterial survival after laundering using different cycle times and temperatures.	Experiment. Two washer extractors.	Increased wash temperature increases the reduction of bacteria but even low temperatures remove most. The type of machine (water volume:load ratio) affects the reduction in bacteria.	Much shorter wash cycles than than contemporary machines. Limited detail on wash/rinse cycles or detergents used.
Jerram P, 1958. An investigation into the ability of laundry processes to kill pathogenic bacteria in soiled articles. To determine whether laundering fabrics at temperature below the standard (90°C) was bactericidal.	Experiment. Laboratory simulated washing machine. 20 tests (bacteria recovered from test fabric by immersion).	Washing at lower than 95–100°C was bactericidal but killing was not complete below 60°C. Alkaline wash liquid enhances killing.	Wash process included 2 minutes at 95–100°C which is a higher temperature than standard laundry processes today. Uses highly alkaline (commercial) rather than domestic detergents. Concentrates on killing bacteria rather than combination of killing and removal.
Barrie D, Wilson JA, Kramer JM, Hoffman P, 1994. Contamination of hospital linen by <i>Bacillus cereus</i> . Description of the laundering process, microbiological sampling, causes of contamination and measures taken to eliminate it.	Case report. Hospital laundry facility. Batch continuous washing machine (BCWM). Sampling methods Microbiological samples were taken from the mains water supply and linen after water extraction and following tumble drying. Test pieces of sterile cotton fabric were sampled after laundering in a BCWM in a 50kg load and as the the sole item. Efficiency of impression sampling was undertaken. Linen was sampled prior to loading into BCWM. Spore burden of 50kg loads of soiled fabric was assessed by sampling 20 ml water on entering the first pre-wash compartment and leaving the second pre-wash compartment.	<i>B. cereus</i> spores were not killed by either the heat or chemical disinfection stage of the wash and were not removed by the dilution in the process. The multiplication of <i>B. cereus</i> was thought to have occurred on contaminated linen stored in plastic bags, particularly when ambient temperatures were high. Increased water flow through the BCWM was the only measure associated with a decrease in <i>B. cereus</i> on laundered linen.	<i>B. cereus</i> is not a common cause of HCAI. This report suggests that adequate water flow and subsequent dilution of contamination is an important stage of the wash cycle.

Continued

Evidence Table 2. Continued

Author, date, title and objective	Design, setting and sample size	Authors' conclusions	Comments on quality and applicability
<p>Tompkins DS, Johnson P, Fittall BR, et al. 1988. Low-temperature washing of patients' clothing: effects of detergent with disinfectant and at tunnel drier on bacterial survival. To compare the effect of triclosan detergent and standard detergent on microbial contamination of patients' clothing.</p>	<p>Experiment. Hospital laundry, washer extractor with tunnel finisher. 10 (crimplene) dresses sampled per day using impression plates taken before process, after wash and after finishing. Samples also taken from final rinse water. Standard detergent used for 1 week, triclosan detergent used for 2 weeks. After washing, dresses put through tunnel finisher (jet of steam, dry heat at 85°C for 5 mins).</p>	<p>There was no difference in the effect of microbial contamination between detergent and triclosan detergent. Most decontamination occurred in tunnel finisher.</p>	<p>Contact plates not a very sensitive method of finding microbial contamination. Microbial load on dress very variable. Variation in bacterial counts each day – variation in initial contamination of load and on one day the use of tumble</p>
<p>Crone PB, 1958. Survival of staphylococci during experimental laundering.</p>	<p>Experiment. Cloth strips inoculated with <i>Staphylococcus aureus</i> and autoclaved milk used as a substitute for soil. Laboratory.</p>	<p>Authors concluded that <i>S. aureus</i> would survive low temperature washing and recommended temperatures of at least 60°C.</p>	<p>“Washing” comprised rinsing without detergent, therefore did not truly simulate the conditions in a washing machine.</p>
<p>Jurkovich P, 2004. Home versus hospital. To determine the presence of pathogens on scrub attire that had been either laundered at home or in the hospital.</p>	<p>Quasi-experimental (pilot study). Self report survey. Operating theatre. Convenience sample of 50 operating department personnel. Home laundered scrubs (n = 30). Hospital laundered scrubs (n = 20). Cultured in first 2 hours of a single work day from front left shoulder.</p>	<p>The results of this pilot study suggested that scrubs laundered both at home and in the hospital were free of pathogens, and that differing home washing procedures made no difference. Further investigation is necessary with larger numbers of subjects.</p>	<p>Small scale study using convenience sample and single measurement of outcome data. No statistical measure of significance and variables not controlled. The small sample means that findings could be a matter of chance.</p>

minating uniforms, or that laundering in domestic machines presents a hazard in terms of cross-contamination of other items in the wash-load with hospital pathogens.

Conclusion and implications for practice

The literature concerning social and patient perceptions of the purpose and importance of uniforms in health care is derived from historical and sociological sources and small scale observational research studies conducted in specific healthcare settings. It is therefore difficult to draw objective conclusions but the following themes are evident in the studies that were reviewed. Uniforms appear to play an important role in the public perception of healthcare professionals. These perceptions are constructed from a range of social and culturally derived images and lead to patients holding particular views about the professionalism and trustworthiness of practitioners based upon the clothes they wear. These images are also used by patients as cues in identifying different disciplines and grades of healthcare staff. The colour and design of uniforms may reinforce socially constructed concepts of cleanliness that result in patients forming expectations that are unachievable. However, despite the limited amount and quality of the evidence, the current perception of the general public is that uniforms pose an infection risk to patients and, when worn outside the clinical setting, the wider public. This perception has been reinforced by media comment and the lack of clear and accessible information. Consequently this belief may have a damaging effect on the relationship of trust that exists between professional carers and patients and the public image of healthcare professionals.

Evidence directly related to the laundering of uniforms is limited. Small scale studies show that uniforms and white coats become

progressively contaminated during clinical care and most microbial contamination originates from the wearer of the uniform. Although some studies theorise that uniforms may transmit HCAI, no studies demonstrated this in practice. A small number of studies evaluated the phases of the wash cycle in hospital laundries for patient linen but not uniforms. They indicate that micro-organisms are removed and killed during laundering, and dilution during washing and rinsing is important. Significant reductions in micro-organisms occur at lower temperatures more commonly used in home laundering. A small number of studies show that home laundering provides effective decontamination. We found no recent studies that accounted for advances in domestic washing machine and detergent technology or that addressed the theoretical infection risk linked with wearing uniforms in public places. It is therefore essential that the findings from these studies are considered in a balanced way and not over-emphasised in the development of uniform policy and that the general principles of infection control continue to be implemented in practice. A copy of the full report is available online at www.richardwellsresearch.com.

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