Bacterial contamination of nurses' uniforms: a study

This study examined the hypothesis that the wearing of plastic aprons during direct patient contact would reduce significantly the number of bacteria carried on nurses' uniforms, and therefore reduce the probability of the transmission of nosocomial infections. Current nursing practices and overall bacterial uniform contamination levels were investigated, as well as the effects of the wearing of plastic aprons to protect uniforms. The conclusions of the study demonstrate that such contamination may be a significant contributory factor in the spread of nosocomial infections, and have implications not only for the nursing profession, but also for other members of the multidisciplinary team. In next week's Nursing Standard, the author examines the difficulties of putting research into practice.

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SEE TABLES

Nurses frequently wipe their hands on unprotected uniforms, a practice that could contribute to nosocomial infections in patients. Community outbreaks of Escherichia coli O157 in Wishaw, Arbroath and Aberdeen in 1997, demonstrated the potential risk of cross-infection to patients and staff, where source outbreaks were characterised by rapid spread in the community and cross-infection was noted in nursing homes, where nursing staff became Escherichia coli O157-positive.

In the Tayside Health Board area, there is no generally agreed policy concerning the wearing of plastic aprons, and the researcher believed that the provision of clear guidelines had the potential to reduce contamination of uniforms and so the risk of trans-mission of nosocomial infections. Consequently, a research study was carried out to examine the effects, if any, of wearing plastic aprons over uniforms to reduce contamination levels.
LITERATURE REVIEW

For some years, the national uniform worn by nurses has been criticised as being impractical in the clinical area (Dring 1987). So contentious has this issue become that nurses in some settings have dispensed with it, and have chosen to wear alternatives, such as trouser suits (Glasper and Miller 1992, Sparrow 1988). Walker and Donaldson (1993) pointed out that 'little time has been devoted to the role of nurses' uniforms as protective clothing, worn to minimise the risks of contamination or infection', and Sparrow (1991) suggested there might be a need for further investigation into the role which uniforms play in cross-infection.

Until the late 1960s, the 'traditional' female nurse's uniform was a cotton dress, covered by a white starched apron which was changed daily. This uniform had changed little since Lees described the use of protective aprons in the 1870s (Yates 1966). Speers et al (1969) conducted a bacteriological study of these uniforms and found them to be clean at the start of the nursing day, but that they became contaminated with Staphylococcus aureus over the course of the day. This study could, in retrospect, be criticised on its statistical analysis of the data, but its conclusions were accepted and the recommendation was made to dispense with the starched apron, and wear a uniform dress that would be changed daily. Protection during wet tasks and wound dressings would be provided by the use of protective plastic aprons.

The possible transfer of organisms from nurses' uniforms as a source of nosocomial infections, and the role of plastic aprons in reducing this means of transmission, was investigated by Lidwell et al (1974) and also in several other isolated studies, mainly in specialised units such as burns units (Hambraeus 1973, Hambraeus and Ransjo 1977, Ransjo 1979, Wong et al 1991).

Little evidence exists concerning the role of plastic in the prevention of cross-contamination, particularly since few of the studies reported whether plastic had been sampled for bacteriological contamination, although Babb et al (1983) noted that, in an isolation ward, fewer organisms were recovered from the front of nurses' uniforms when plastic aprons instead of gowns were worn, and that plastic aprons could carry organisms.

Handwashing practices among nurses and patients have been researched extensively, and all authors agree that poor handwashing practices contribute to nosocomial infections (Casewell and Phillips 1977, Fox et al 1974, McFarlane 1990, Pritchard and Hathaway 1988, Sedgewick 1984, Taylor 1978 a and b).

No recent research has examined the current bacteriological status of nurses' uniforms in general hospital wards, and the implications for the transmission of nosocomial infections.

AIMS OF THE STUDY

The aims of the study were to examine levels of bacterial contamination on nurses' uniforms and the role, if any, that plastic aprons might play in the reduction of these levels of contamination by acting as a barrier between the uniform, a possible reservoir of bacterial contamination, and the patient.

It became apparent during the pilot phase that subsidiary aims should be defined, such as the need to determine how nurses handled,
laundered and stored their uniforms, since these practices appeared to contribute to the levels of bacterial contamination observed. No attempt was made to identify individual organisms. The intention was to identify the total levels of all type of bacteria present, including potential pathogens, thus identifying a risk to patients and staff.

MATERIALS AND METHODS
The research was conducted in two phases, a pilot study and a subsequent comparative study. The research methods were tested in the pilot study and, using those techniques identified as the most appropriate, and with the preliminary data obtained, the comparative study was carried out.

The pilot study was carried out in two male and female general surgical and two male and female orthopaedic wards, and compared contamination levels on nurses' uniforms at three sites (chest, waist, and buttock on the dominant hand side) at three times in the nursing shift; beginning, mid-shift, and end of shift.

Two sampling techniques and two culture media were tested: the application of direct contact plates of salt agar and blood agar culture media to the selected uniform sites, and the inoculation onto blood agar and salt agar culture plates of samples taken from the same sites using moistened sterile cotton buds. Contact plate sampling was deemed aesthetically inappropriate: the more suitable culture medium, blood agar, discoloured the nurses' uniforms. The sampling technique using moistened sterile cotton buds grew comparable numbers of bacterial colonies on the culture plates.

The sampling technique identified in the pilot study as 'best practice', validated by the supervising professor of medical microbiology, and subsequently used in the comparative study, was the use of a sterile cotton bud, moistened with sterile saline, drawn across the area to be sampled in a Z-pattern, and then inoculated directly onto blood agar culture plates, which were then removed for incubation immediately.

The samples were cultured on blood agar plates at 37°C for 18-24 hours and the colony count recorded. Blood agar was chosen as it is a less selective growth medium than salt agar, and grew a wider range of bacterial colonies, so providing better identification of overall levels of contamination. No attempt was made to identify individual species of organisms: all organisms were deemed to be potentially pathogenic because the bacteria (which is what was being measured) are there and can cause diseases in patients, particularly those who are immunocompromised. Instead, total levels of contamination were estimated by colony counts from the standardised sampling technique described earlier. ‘Heavy’ contamination was defined, on bacteriological advice (Speers et al 1969), as equal to or greater than 20 colonies per sampling agar plate.

Following the pilot study, a comparative study was performed in another hospital, where nurses in two wards, caring for immunocompromised patients (renal dialysis and haematology) were studied in an identical fashion. In one of the wards, nurses routinely wore protective plastic aprons. These were also sampled on identical sites as for the uniforms underneath. In the other ward, plastic aprons were not worn.

In all, 88 nurses' uniforms were sampled: 48 during the pilot study and 40 during the comparative study. Protective plastic aprons were sampled in the same way in the comparative study, as were uniforms on
carousels and in the laundry. Up to 2,000 separate bacteriological studies were performed.

The data were analysed on Minitabs and SPSS programs. Analysis of variance was performed, and the results demonstrated as mean values, with significance levels expressed as ‘p’ values.

RESULTS
It was anticipated, in view of the original data from Speers et al (1969), that increasing levels of bacterial contamination of nurses’ uniforms would be observed during the working day, and that certain sites, for example, the buttock area, would be more heavily contaminated than other sites. Instead, uniforms were found to be equally and heavily contaminated at all sites sampled, and at all times – at the start of the working day, at mid-shift, and at the end of the nursing shift, with no statistically significant differences being observed.

Wide individual variations of bacterial contamination were observed: some uniforms carried more than 400 colonies per plate, at each site sampled. It should be noted that, at higher levels of contamination, colonies merged, becoming uncountable at greater than 400 colonies, so the upper limit of contamination was not identified. Consequently, the figures shown in the tables represent the mean colony counts, and these tend to obscure wide individual variations.

Similar data were found from both the pilot and comparative studies (Tables 1 and 2), and the wearing of plastic aprons was not associated with significantly less bacterial contamination on the uniforms underneath (Table 3). The plastic aprons were themselves heavily contaminated (Table 4), with individual counts of >300 colonies/site.

The data demonstrated heavy levels of contamination on nurses’ uniforms throughout the working shift, and also unacceptably high levels of contamination of the plastic aprons. The use of plastic aprons was not associated with any statistically significant alteration of observed levels of bacterial contamination on equivalent sites on the uniforms underneath: some uniforms were heavily contaminated and others were only lightly contaminated and, although the plastic aprons were significantly less contaminated than the uniforms, the overall levels of contamination on the plastic aprons still equated to ‘heavy’ contamination.

The use of plastic aprons did not, therefore, appear to alter bacterial contamination of the uniforms, and these data, despite the observation by Lidwell et al (1974) that, ‘when uniforms are protected by a plastic apron, Staphylococcus aureus was almost eliminated’, may contradict the statement by Wilson (1990) that plastic aprons provide ‘a poor environment for bacterial growth’.

As a result of the bacteriological findings of the comparative study, the reasons for the heavy contamination of both uniforms and plastic aprons were investigated.

It was assumed that nurses’ uniforms were sterile at the end of the hospital laundering process, and that plastic aprons were sterile at the point of manufacture. To investigate the observed subsequent uniform contamination, the laundering, distribution and handling of uniforms were studied – by preparing a questionnaire that was distributed to 224 nurses working in three hospitals all supplied by the same laundry (on-site at the largest of the three hospitals surveyed). Questions related
to the number of uniforms issued per nurse; the use the hospital laundry or any other means of uniform laundering, including the use of domestic washing machines or other means of home laundering; how many uniforms were supplied; how nurses stored these uniforms after collection; whether nurses travelled to and from work in their uniforms; and whether or not a fresh uniform was worn at the start of each nursing shift. The use of plastic aprons and their storage and handling was also investigated. The response rate to the questionnaire survey was more than 90 per cent.

Change of uniform Overall, 60 of 196 respondents did not wear a fresh uniform daily (30.6 per cent). No significant differences were noted between the three hospitals, suggesting that the presence of the laundry on-site did not improve the rate of wearing of fresh uniforms. On the ward where aprons were worn routinely, fewer nurses (7.3 per cent) wore a fresh uniform daily than in the corresponding ward (27.8 per cent) where aprons were not worn routinely. This high rate of not wearing a fresh uniform at the start of the nursing shift in the 'apron-wearing ward' was investigated specifically: the nurses responded that: 'Organisms do not cling to plastic, and so we do not need to change our uniforms every day.' This suggests that nurses rely on protective plastic aprons to keep uniforms clean. The stated reasons for not wearing a fresh uniform included (in order of decreasing frequency):

- 'Not back from the laundry.'
- 'Not enough uniforms.'
- 'If my uniform looks clean, then I don't change it.'
- 'I only had a half-shift, so I used the uniform again.'
- 'No dressings to do.'
- 'We wear plastic aprons and organisms do not cling to plastic.'

Laundering uniforms Overall, 69 per cent used the hospital laundry all or most of the time, although the frequency of use of the laundry significantly differed between hospitals: nurses employed in district hospitals used the laundry significantly less often (overall, 53 per cent) than in the teaching hospital, where the laundry was sited (79 per cent, p<0.01). Conversely, nurses in the district hospitals tended to launder uniforms at home more often than nurses in the teaching hospital (overall, 44 per cent compared to 26 per cent, p<0.01).

The hospital laundry ensured that uniforms were sterile at the end of the laundering cycle by adding disinfectant during the wash cycle. This was checked by sampling uniforms fresh off the laundry line in an identical fashion to the rest of the study: 12 uniforms were selected randomly, and no bacteria were recovered using the test method employed in the comparative study.

Home laundering was considered by Ayliffe (1989) to be insufficiently controlled to render uniforms sterile, since the uniforms would be washed often with other items of clothing – a practice likely to increase cross-contamination of these other items of clothing with hospital-acquired organisms. He noted that increasingly, domestic washing machines were being used in 'small units', since it was felt that hospital laundries could damage personal clothing, such as knitted items. These machines were considered acceptable where those using the clothing were reasonably healthy, but not for infected or immunocompromised patients.

When nurses’ home laundering practices were examined, most washed their uniforms in a mixed wash at low temperatures (40°C), and only 11
per cent washed their uniforms at a level regarded as bactericidal (>90°C), a boil wash, although the uniform material is recommended to be washed at no higher than 65°C.

This observation stimulated further tests to ascertain whether or not a 'safe' home laundering protocol could be developed. In a small-scale supervised study, 15 freshly hospital-laundered uniforms were deliberately contaminated with a standardised preparation of Serratia marcescens, which was allowed to dry for 60 minutes; these were then washed in the researcher's domestic washing machine at the variety of temperature settings, wash cycles, and mixes which had been identified in the questionnaires. Serratia marcescens was chosen as a suitable 'marker' organism for such studies on the basis of expert bacteriological advice. A sterile theatre drape was added to each load to act as a control, and to identify cross-contamination. After laundering, the uniforms and drapes were air-dried or tumble-dried at standard settings, and subsequently ironed at hot settings. The results are summarised in Table 5, showing that uniforms could be safely laundered at home, provided that they were washed with no other items of clothing, at not less than 50°C, and then ironed dry with a hot iron. Since the uniform material can be washed at 65°C, it would probably be preferable for these uniforms to be washed with no other items at this higher temperature, and then ironed when dry with a hot iron. Samples were taken from the completely laundered uniforms at the end of each experiment, using the standardised technique described earlier. Due to the slower growth characteristics of Serratia marcescens, the plates were cultured for 48 hours rather than the usual 24 hours.

**Storage of uniforms and aprons**

The way in which nurses stored and handled their uniforms after collection from the laundry carousel or after home laundering was also examined. Wide variations were noted: some nurses made attempts to store their uniforms carefully, but many made no attempt to do so; uniforms were stored in shopping bags, in the back of cars, in car boots, and when nurses changed, the uniforms were often left on dusty surfaces. In addition, wide variations in changing facilities were noted. In one hospital area, the changing facilities were so poor that nurses often were obliged to change in the WC, placing their uniforms on the seat of the WC when changing from their outdoor clothes.

The storage, handling and use of plastic aprons were also investigated. In the apron-wearing ward, plastic aprons were stored on a roller, which was sited directly above the waste disposal bin in the 'clean' preparation room. It was noted that when an apron was torn off the roll, the tail of the next apron tended to lie across the lid of the disposal bin. When the surface of the bin lid was sampled, heavy bacterial contamination was identified. On one occasion, the roller was empty and loose aprons were piled on the bin-lid. These then fell to the floor and were restacked on the bin-lid.

It was noted that nurses did not usually wash their hands before putting on a fresh apron. Since no protocol existed regarding the use of plastic aprons, nurses used the aprons in a self-directed manner, and did not necessarily change these aprons for different tasks. Often, aprons were worn for long periods for a variety of tasks.

**DISCUSSION AND RECOMMENDATIONS**

The initial hypothesis, that the wearing of plastic aprons during direct patient contact would significantly reduce the number of bacteria carried on nurses’ uniforms, and thereby reduce the probability of nosocomial infections, was not confirmed.
This study demonstrated instead that nurses are wearing uniforms which are heavily contaminated with a variety of bacteria, and that current use of plastic aprons does not prevent bacterial contamination of these uniforms. The original findings of Speers et al (1969), that nurses’ uniforms became progressively more contaminated throughout the nursing day, were not confirmed: instead, nurses' uniforms were shown to be heavily contaminated at all sites sampled throughout the nursing day, and that nurses’ practices concerning laundering, storage and handling of uniforms probably contributed to these high levels of contamination.

In addition, the use of plastic aprons was shown to be associated with no significant reduction in levels of contamination of the underlying uniforms, and serious misunderstandings among nurses concerning the ability of bacteria to cling to plastic meant that nurses’ reliance on the use of plastic aprons to keep their uniforms uncontaminated was inappropriate, and consequently they wore their uniforms for more than one day.

This does not mean that plastic aprons should not be used: although high levels of contamination were noted on the aprons, these were significantly less than on the uniforms underneath, although it should be noted that some aprons were very heavily contaminated. The perception that bacteria do not adhere to plastic is not supported by the data. Appropriate protocols for the storage, handling and use of plastic aprons would probably reduce the contamination levels on the aprons, thus providing an impermeable barrier between the nurses' uniforms and patients, and possibly reduce the transmission of bacteria between nurses and patients. A suitable protocol was devised by Curran (1991) and this has been adapted for use in one of the areas that participated in the study (Box 1).

A common observation among nurses who wore their uniforms for more than one day was that they simply did not have a clean uniform available. Managers should ensure that nurses have sufficient uniforms to enable them to change into a fresh uniform daily (not less than nine uniforms per nurse to allow for turn-around times for laundering and delivery), and that hospital-laundered uniforms should be kept sterile by ensuring that they are sheathed in protective plastic covers immediately after laundering. Generally, part-time nurses were issued with only three uniforms, however, they should also be issued with the same number of uniforms as full-time nurses.

Where nurses launder uniforms at home, either because hospital laundering is impractical or unavailable, they should be encouraged to use an effective home laundering protocol, such as that outlined in Box 2. This could prove to be particularly useful for community nurses, who do not have access to hospital laundering facilities, and increasingly for student nurses who are not employed by trusts.

CONCLUSION

The laundering of protective clothing or uniforms should comply with all of the recommendations for nurses' uniforms, and when direct patient contact is involved, nurses should also be protected with plastic aprons to prevent wetting and soiling of their uniforms or of their own clothing.

The researcher noted that nurses’ awareness of the various means of transmission of nosocomial infection was generally poor, and that standards of handwashing hygiene, in particular, were low. Nurses were
not aware of the potential relationship between the carriage of bacteria on uniforms or aprons and nosocomial infections. They appear to have difficulty in relating theory to clinical practice. Rigorous continuing education programmes for both pre- and post-registered nurses are required to heighten and sustain awareness of this ongoing problem.

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