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The dispersal of bacteria and skin scales from the body after showering and after application of a skin lotion

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SUMMARY

Application of a skin lotion to the body after showering greatly reduced the number of bacteria and skin scales dispersed from 10 men and 10 women. This effect lasted for at least 4 h when surgical clothing was worn. The use of a skin lotion to reduce bacterial dispersal could provide a simple and inexpensive alternative to an ultraclean air system or uncomfortable operating clothing during surgery requiring these procedures.

INTRODUCTION

Bacteria are released from the human body into the air upon shed skin fragments (Noble, 1961; Davies & Noble, 1962). Most of these are detached by the abrasive action of fabrics (Hill, Howell & Blowers, 1974; Benediktsdottir & Hambraeus, 1982) which they penetrate and from which they escape via openings in the weave (Charnley & Eftekhar, 1969; Schwartz & Saunders, 1980). They are dispersed in the convective flow of warm air around the body and by the bellows action of clothing (Clark & Cox, 1973).

Bacterial dispersal after showering has been investigated, but results have not been consistent. Speers *et al.* (1965) found that the number of bacteria dispersed increased for approximately 30 min in most people they examined. Bethune *et al.* (1965) found that the number of *Staphylococcus aureus* dispersed increased in some people sometimes. Cleton, van der Mark & van Toorn (1968) found no consistent effect of showering on the dispersal of commensal bacteria, or of transient *S. aureus*. Increased dispersal following showering has been assumed to be due to the buffeting action of water droplets loosening skin scales ready for detachment (Clark & Cox, 1973), but no evidence has been advanced for this view. The effect of showering on the dispersal of bacteria and skin scales is poorly understood, and some surgeons have requested information from this department about its usefulness before surgery.

For many years dispersal of skin bacteria from surgical clothing, either by transfer from its surface or by an aerial route, has been believed to occur, resulting in wound sepsis. Therefore, methods of preventing release and dispersal have been

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investigated. Release was reduced by coating skin with a lanolin cream or 70% ethanol (Bernard *et al.* 1965*a*), but the procedure has been reported to be inconvenient, time-consuming and not generally acceptable (Clark & Cox, 1973). Dispersal may be reduced by wearing gowns made from closely woven fabrics (Charnley & Eftekhar, 1969; Hambraeus & Ransjo, 1977; Lidwell, Mackintosh & Towers, 1978), exhaust suits (Lidwell *et al.* 1982), tightly fitting Neoprene sponge rubber underpants (May & Pomeroy, 1973) or disposable, non-woven paper gowns (Whyte, Vesley & Hodgson, 1976; Mitchell, Evans & Kerr, 1978). However, surgeons have found that clothing made from these materials was uncomfortable or impractical in use and they have never been widely accepted. Another occlusive fabric, 'Gore Tex', also reduced dispersal but was reported to increase perspiration (Matthews, Slater & Newsom, 1985). More complex methods of reducing dispersal which combine protective clothing with ultraviolet irradiation of the theatre (Bernard *et al.* 1965*b*) have also not been widely adopted. None the less, Lidwell *et al.* (1982) provided evidence that there was a greater incidence of post-operative wound sepsis or endocarditis during insertion of joint prostheses or cardiac valve surgery from aerial dispersal of skin bacteria when dispersal was not controlled.

In this study, the dispersal of bacteria and skin scales was estimated before and after showering, and after application of a skin lotion, with and without traditionally preferred operating clothes made from a loosely woven cotton fabric.

MATERIALS AND METHODS

A shower cabinet, 2 m high by 1·2 m wide by 0·8 m deep, was modified for use as an air sampling chamber by covering the top with a plastic hood. Air, filtered to remove particles $> 5\ \mu m$ diameter, was blown in the top from a filter-blower at the rate of 100 l min^{-1}. A shelf, 0·3 m high, situated at the rear of the cabinet carried a metronome set at 84 beats min^{-1} and two Casella 'Mark 2' bacterial slit-samplers (Casella Ltd, London) set to sample 175 l air min^{-1}, positioned side by side. The samplers were connected in parallel to a fan pump, the tubing from which passed out through holes cut in the panels of the cabinet wall. The cabinet was situated in an unused room in which another filter-blower was running.

Each slit-sampler contained one 14 cm diameter plate of nutrient agar (Nutrient Broth no. 2 solidified with 1·5 g l^{-1} agar; Oxoid Ltd, UK) and had a turntable which either revolved, for the estimation of bacterial numbers, or was stationary, for the estimation of skin scales. Scales were deposited within a rectangular trace of area 61·5 mm^2 on the surface of the agar. Plates were either incubated at 32 °C overnight, followed by 1 day at room temperature and the number of bacterial colonies arising counted, or they were retained at 4 °C and the number of skin scales counted when convenient. If there was a light or moderate skin scale deposit, the number in a band of area 49·2 mm^2 in the centre of the trace was counted: if the deposit was heavy, the number in five randomly chosen bands, each of area 4·8 mm^2 was counted. Scale counts have been expressed as number in the entire trace area, as scale deposition over the agar surface was uniform.

Volunteers wore clean underclothes and shower caps and walked on the spot in the cabinet in time with the metronome for 3 min, air being sampled for the last 2 min. Air was blown into the cabinet for at least 5 min between sampling

occasions to reduce bacterial counts to background numbers. Volunteers showered for 2 min using plain soap and patted themselves dry with towels, creating as little friction with their skin as possible. A 15% oil-in-water emulsion ('Unperfumed skin lotion', Boots plc, Nottingham, UK) was applied *ad libitum* by each volunteer all over his/her body (except the back and face).

Statistical tests were done on each dataset obtained after application of the transformation $y = \sqrt{x}$, since variances were usually the same as means, and these two parameters were not positively correlated (Sokal & Rohlf, 1981).

The effect of air sampler position on the collection of bacteria and skin scales

Volunteers did not shower in this preliminary experiment. Four samples of bacteria and skin scales were taken from each of three males exercising in the cabinet, the samplers being interchanged (left and right) as necessary in a random order. Counts were analysed by a two-way analysis of variance.

The effect of showering on the dispersal of bacteria and skin scales from the body

Duplicate air samples were taken from 10 men and 10 women before and after showering, and after application of the skin lotion. All were healthy except for one man who had psoriasis. The age range of men was 21–38 years, and that of women 21–43 years. Control samples for background numbers of bacteria were taken in the unoccupied cabinet 5 min before each volunteer showered. Between sampling different people, at least 30 min elapsed and the cabinet floor was disinfected with an alcohol-soaked wipe. The interval between duplicate samples was 2–32 days. The average number (±S.E.M.) of bacterial colonies, and of skin scales collected at each stage in the experiment was determined. Differences between the average counts before and after showering, and between showering and applying the lotion were tested for significance using paired t tests. Two-tailed probability levels were used for the former and one-tailed probability levels for the latter test. The reproducibility of the effect of showering on the number of bacteria and skin scales dispersed between the two sampling occasions was determined for all 20 people, and for a group of 6 'high dispersers' (Evans, 1975) selected from these people.

The effect of successive application of the skin lotion to parts of the body in males

Air was sampled from four men before and after showering, and after successive applications of skin lotion to their arms, legs, trunk (except back) and perineum. The number of skin scales and bacteria collected at each stage was recorded.

Determination of the duration of reduction in dispersal of bacteria and skin scales after application of the lotion

Successive air samples were taken from three men before and after showering, after application of the lotion, and at 30 min intervals during exercise in the cabinet for 4 h while wearing underclothes. The men wore street clothes between air sampling.

Reduction in dispersal from volunteers wearing surgical clothes after application of the lotion

Successive air samples were taken from three men each wearing sterilized surgeon's trousers, shirt, mask, cap and gloves after showering and then every

Table 1. *Numbers of bacteria and skin scales collected from three male volunteers using air samplers at two positions in a sampling chamber*

		Volunteer			Position	
		1	2	3	Left	Right
Bacteria (c.f.u.)	Average count	1293 (4)	140 (4)	296 (4)	528 (12)	612 (12)
	S.E.M.	138·2	13·3	70·8	162·1	178·4
Skin scales	Average count	6535 (4)	77 (4)	3018 (4)	3626 (12)	3254 (12)
	S.E.M.	578·8	62·5	453·6	746·0	838·9

hour for 4 h. At the end of this period one sample was taken from volunteers wearing underclothes alone to exclude the abrasive effect of the loosely woven cotton. Successive samples were then taken after volunteers had showered again, applied the lotion, dressed in a fresh set of sterile surgical clothing and repeated the hourly exercise for 4 h in the cabinet, after which a further sample was taken from volunteers wearing underclothes alone.

The antibacterial effect of the lotion

This was done to determine whether the preservative system in the lotion was responsible for reduced recovery of skin bacteria after it had been applied to skin. Two adjacent sites on the left forearm of three people were selected, 0·5 cm^3 of the lotion was applied in a random manner to one of the sites on each volunteer's arm and left for 5 min. Scrub cups (Williamson & Kligman, 1965) were placed over each site and 1 cm^3 of 0·075 M phosphate buffer with 1 $cm^3\ l^{-1}$ Triton X-100 and 30 $cm^3\ l^{-1}$ 'Tween-80' (pH 7·9) was added. The skin surface was scrubbed with a flat-ended glass rod for 1 min and repeated. The duplicate fluid samples were pooled, 1 cm^3 plated on to nutrient agar and incubated as before. The counts were analysed using a two-way analysis of variance.

RESULTS

There were very highly significant ($P < 0·001$) differences between the numbers of bacteria and skin scales collected from individuals, but no significant difference between the numbers of each collected at the two sampler sites (Table 1). Therefore, the position of the sampler in the cabinet did not affect the collection of bacteria or skin scales. In further experiments bacteria were collected with the sampler in the left position and skin scales with the sampler in the right.

Men dispersed many more bacteria than women, confirming the results of Bethune *et al.* (1965), Ayliffe, Babb & Collins (1973), Noble *et al.* (1976) and several other workers. For both men and women, there was no significant difference between the number of bacteria or skin scales dispersed before and the number dispersed after showering, but there were very highly significant differences ($P < 0·001$) between the numbers of bacteria and skin scales dispersed after showering and the number dispersed after application of the lotion (Figs. 1, 2). There was no consistent effect on the numbers of bacteria or skin scales dispersed

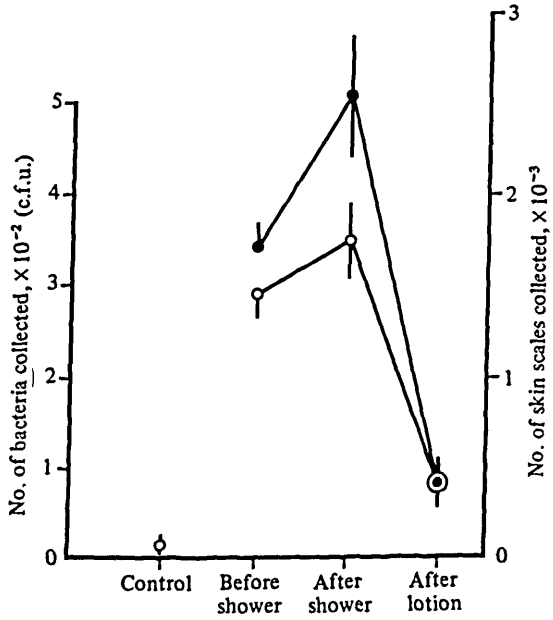

Fig. 1. Average number (±S.E.M.) of bacteria (○) and skin scales (●) collected in duplicate samples from 10 males ($n = 20$).

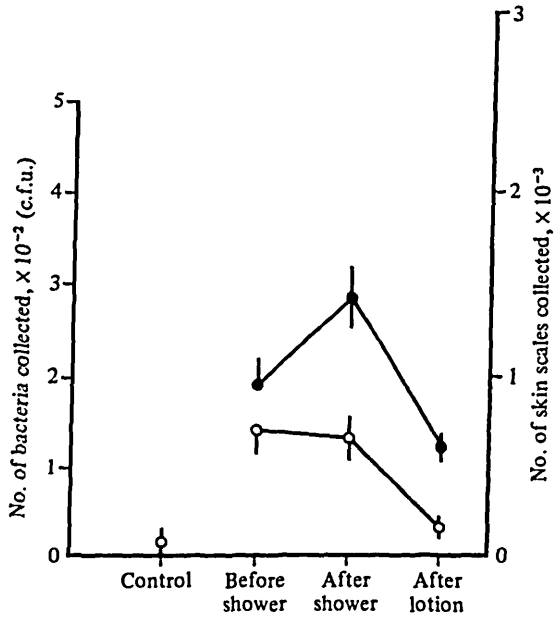

Fig. 2. Average number (±S.E.M.) of bacteria (○) and skin scales (●) collected in duplicate samples from 10 females ($n = 20$).

by the 20 people examined (Table 2) or the subset of 6 'high dispersers' (Table 3) between the two sampling occasions.

Larger reductions in the number of bacteria and skin scales dispersed were found after application of the lotion to legs and perineum than when it was applied to

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Table 2. *Reproducibility of the effect of showering on the numbers of bacteria and skin scales dispersed from 10 males and 10 females on two sampling occasions*

		No. dispersed increased twice	No. dispersed decreased twice	No. dispersed increased and decreased
Men (10)	Bacteria	5	2	3
	Skin scales	4	2	4
Women (10)	Bacteria	3	4	3
	Skin scales	6	2	2

Table 3. *Reproducibility of the effect of showering on the numbers of bacteria and skin scales dispersed from six 'high dispersers'*

		Bacteria (c.f.u.)		Skin scales	
Sex of volunteer	Sampling occasion	Before shower	After shower	Before shower	After shower
M	1	893	354	3892	3323
	2	464	455	4403	3110
M	1	199	316	363	559
	2	487	372	730	481
M	1	344	151	1468	2931
	2	58	124	909	3021
M	1	393	1910	3725	10662
	2	79	173	1728	902
F	1	469	365	4493	5421
	2	228	481	1223	5082
F	1	1660	928	3571	2982
	2	293	182	2368	1318

the arms and trunk (Fig. 3). These results are consistent with those obtained by May & Pomeroy (1973), who found that bacteria were dispersed mainly from the perineum in men, and by Bernard *et al.* (1965*a*) who used a lanolin cream to control bacterial dispersal.

The numbers of bacteria and skin scales collected from men were much lower after application of the lotion than those collected after showering, and remained much lower for at least 4 h when street clothing was worn between samplings (Fig. 4). When surgical clothing was worn during sampling, the numbers of bacteria and skin scales dispersed after showering were only slightly reduced, but they were greatly reduced and their numbers remained much lower when the lotion was applied to the body for at least 4 h (Fig. 5).

Results from the experiment to determine the antibacterial properties of the lotion showed there was a significant difference ($P < 0{\cdot}05$) between the numbers of bacteria recovered from the three people, but no significant difference between the numbers recovered with and without the lotion. Therefore the lotion has no antimicrobial action measurable by this technique after application to skin. Counts of bacteria recovered are shown in Table 4.

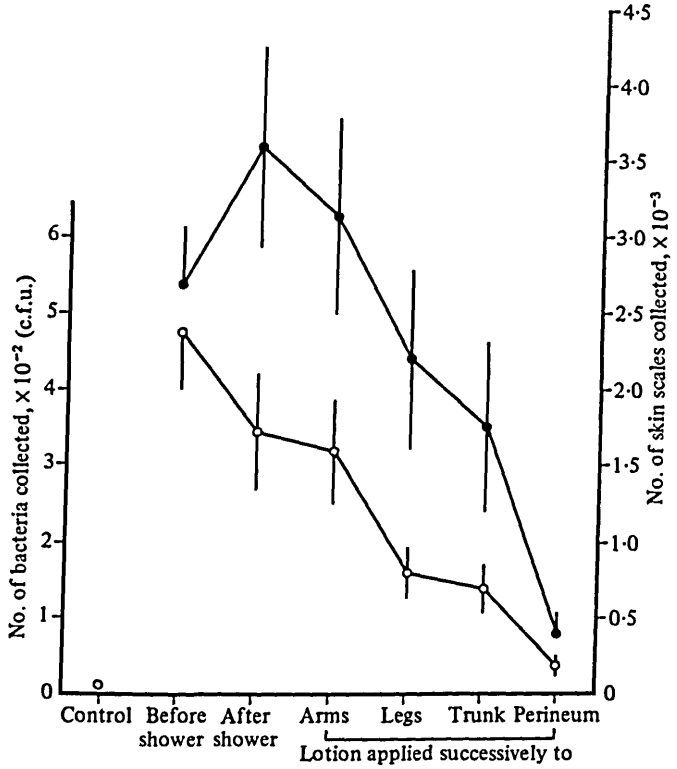

Fig. 3. Average number (±S.E.M.) of bacteria (○) and skin scales (●) collected from four males during sequential application of a skin lotion to body parts.

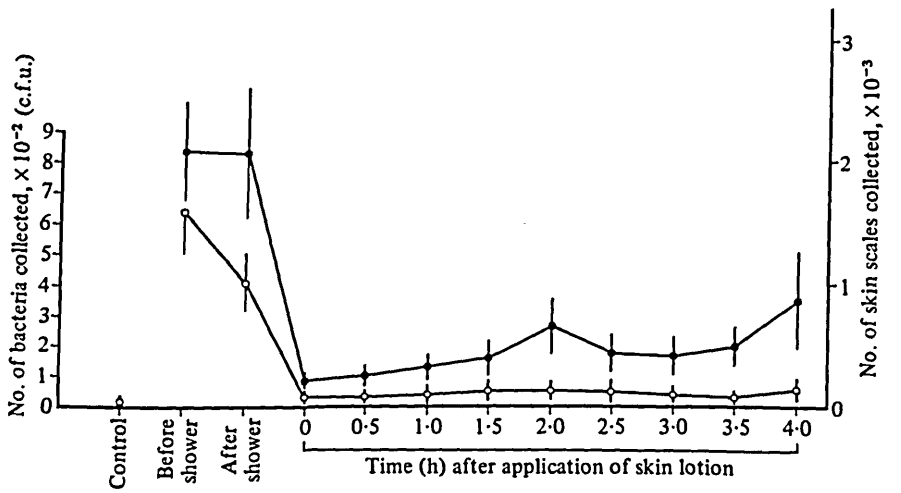

Fig. 4. Average number (±S.E.M.) of bacteria (○) and skin scales (●) collected from four males after application of a skin lotion to the body.

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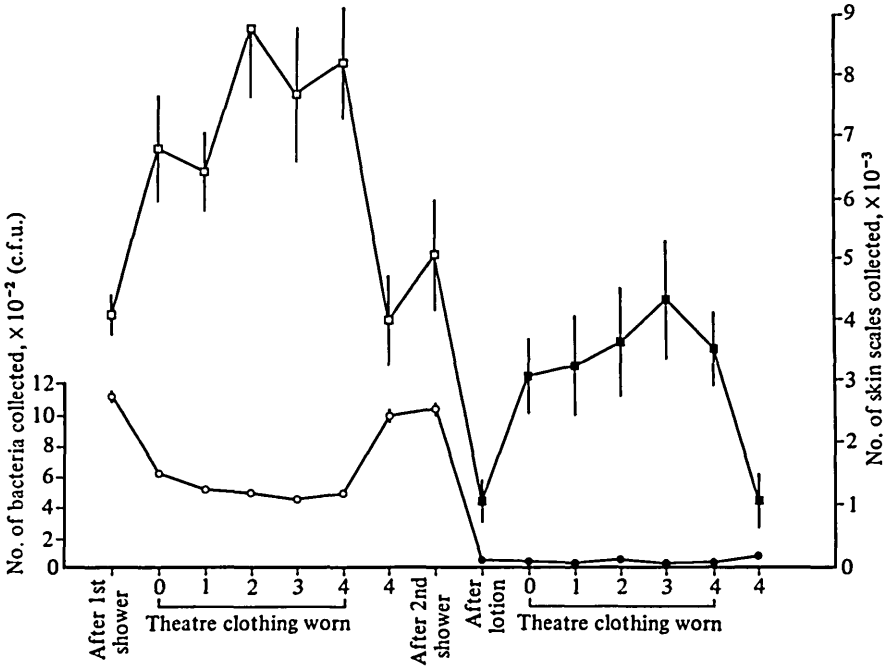

Fig. 5. Average number (±S.E.M.) of bacteria (○) and skin scales (□) collected from three men dressed in theatre clothing before and after (●, ■) application of a skin lotion to the body.

Table 4. *Numbers of bacteria (c.f.u.) recovered from skin scrub samples from two adjacent sites plated on to nutrient agar at 32°C overnight followed by 1 day at room temperature*

	Volunteer		
	1	2	3
With skin lotion	81	76	283
Without skin lotion	71	105	253

DISCUSSION

On average, showering did not significantly or consistently affect the number of bacteria dispersed from 20 people. These findings were also true for 'high dispersers' and refute the belief that this group always disperse more bacteria after showering. Our results for bacterial dispersal after showering are consistent with those published by Cleton, van der Mark & van Toorn (1968). Matthews, Slater & Newsom (1985), in their studies on the ability of an occlusive fabric to retain dispersed bacteria, required their volunteers to shower before testing the fabric to 'reduce as far as possible any individual variations of dispersal'. Our results show that their assumption was invalid.

A much smaller number of bacteria and skin scales were dispersed from men and

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from women after application of the lotion to the body. This effect is most likely to be due to the adhesive action of the lotion. The level of reduction in dispersal of bacteria achieved by the use of the lotion is at least as good as that achieved by protective clothing in laboratory experiments.

More bacteria and skin scales were dispersed when surgical clothing was worn compared with underwear, demonstrating that surgical clothing abrades the skin surface releasing large numbers of scales. When skin lotion was applied, the numbers of bacteria and skin scales dispersed was reduced despite removing and replacing street clothing, and movement in surgical clothing while waiting between samples, which activities normally release large numbers of bacteria and skin scales (Duguid & Wallace, 1948).

The failure of researchers to consider the comfort of theatre staff during surgery has resulted in the abandonment, or refusal to adopt several methods which were effective in reducing dispersal of bacteria. But the problem of post-operative sepsis caused by skin bacteria during joint prostheses and cardiac surgery still remains. Meers (1983) contended that antibiotic prophylaxis was a simpler, cheaper and more effective alternative to the use of expensive ultra-clean air systems and uncomfortable clothing currently used and proposed by Lidwell *et al.* (1982). The results of our study suggest that a skin lotion might also reduce the post-operative sepsis rate caused by bacteria originating from theatre staff and is an equally simple and cheap alternative. The lotion could also be used as a control measure in burns or isolation units, either routinely or in an emergency.

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