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The importance of soap selection for routine hand hygiene in hospital

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SUMMARY

Five different types of liquid soap were studied in hospital wards, each during two months' use. Altogether 1306 finger print samples were taken from the hands of the staff by sampling twice a week and the acceptability of the soaps was measured by a questionnaire. During the use of different soaps only slight differences were found in the numbers of total bacteria or in the occurrence of *Staph. aureus* and gram-negative bacilli on the hands. During the use of the emulsion-type product studied, several persons who had dermatological problems had lower mean bacterial counts of the fingers than during the use of the other soaps. This soap was also favourably accepted by the staff. After over one year's use of pine oil soap and alcohol, the staff of the hospital was satisfied with the method. However, several persons with skin problems admitted to not using soap or alcohol. The considerable differences found in the acceptability of soaps imply that for use in hospital the choice of a soap acceptable to the nursing staff is important in promoting proper hand hygiene.

INTRODUCTION

Ordinary liquid soap is widely recommended for routine hand hygiene in hospitals when there is no special reason for disinfection. This recommendation is supported by studies showing that the effectiveness of hand hygiene does not depend greatly on the preparation used (e.g. Weatherall & Winner, 1963; Lowbury Lilly & Bull, 1964; MacPherson, Sparkman & Whitney, 1965; Mortimer, Wolinsky & Rammelkamp, 1965; Sprunt, Redman & Leidy, 1973). It is known that all soaps are not favourably accepted by the nursing staff. However, little attention has been paid to their selection for hospital use. In a previous study dermatological problems in the hospital were found to correlate with high bacterial counts of the fingers during frequent use of a disinfectant preparation (Ojajärvi, Mäkelä & Rantasalo, 1977). The purpose of the present study has been to find out whether different soaps used in hospital wards differ in their acceptability and whether these differences correlate with the bacterial flora of the hands.

MATERIALS AND METHODS

Soaps

Five liquid soap products were chosen for the study:

Soap A: A soap containing triethanolamine as detergent, with pH 9·0.

Soap B: An emulsion based product used for hand hygiene in Finnish hospitals containing ionizing detergents, pH 6·0.

Soap C: A soap specially designed to be acceptable in frequent use. The product contains an ampholytic detergent and potassium salts of fatty acids, pH 8·3.

Soap D: A sodium soap of pine oil, pH 9·5.

Soap E: A potassium soap of pine oil, pH 9·5.

Fat removing capacity of the soaps

To further characterize the soaps studied, their fat removing capacity was determined by shaking glass plates layered with lard in 1 % soap solutions for 30 minutes in a shaker at room temperature. Water was used as a control. The plates were weighed before and after shaking. Five tests were performed with each soap solution. The mean weight of dissolved fat was calculated, excluding the highest and lowest values.

Laboratory tests with volunteers

The ability of different soaps to remove *Staph. aureus* or *Pseudomonas* from artificially contaminated finger tips was tested as described earlier (Ojajärvi, 1980). The washing time was 15 s. The tests were done according to a Latin square design with a group of six volunteers who had no skin problems. Bar soap and plain water rinse were also tested.

In-use study in wards

The hospital study was conducted in four wards of The Children's Clinic, University of Helsinki. Two wards used the same soap at a time. Each soap was used for two months before adopting the new one. All wards used three different soaps in sequence. During the study no hand disinfectants or other soaps were used in these wards. Before the study, an emulsion containing hexachlorophene had been used in the wards for hand washing.

The study was conducted in winter, from October to May. The average outdoor temperature during the study period did not markedly differ from the long-term records of the district. The mean monthly temperature varied from + 6 °C to − 8 °C.

Sixty-two female members of the staff participated in the study. The age differences among the staff of the different wards were not marked. The mean age of the 27 nurses was 35 years, that of 33 auxiliary nurses 42 years. Two persons were laboratory nurses. The mean hand washing frequency in different wards varied from 11 to 24 times per 8 hours working shift, except in ward 4, where the mean frequency was 44 times per shift. The mean hand washing frequency of the nurses was 20 times, that of auxiliary nurses 30 times per shift.

Bacteriological methods

Bacterial sampling of the hands was started after two weeks' use of each soap. After hand washing and subsequent drying with a disposable paper towel, samples were taken twice a week (Tuesday and Thursday) on blood agar plates using finger print techniques (Ojajärvi *et al.* 1977). The plates were incubated aerobically at 37 °C overnight and kept for another night on the laboratory bench before counting bacterial colonies. Special attention was paid to the occurrence of *Staph. aureus* and gram-negative bacilli.

Altogether 1306 bacterial cultures were taken from the hands during the study. Due to the nature of hospital work, only 60 % of the staff could be sampled on each day of sampling. On the average, seven samples were obtained from one person during the use of each soap.

The acceptability of the soaps

At the end of each test period the participants answered a questionnaire concerning the acceptability of the soaps. The staff were asked to compare the soaps with those used earlier. Previous dermatological problems, the use of hand emollients, and possible untoward effects occurring during the use of the soaps studied were also recorded in the questionnaire.

Continuous use of pine oil soap and alcohol

The method adopted for routine hand washing in the hospital involved the use of a pine oil soap followed by disinfection with 80 % ethanol containing 0·5 % chlorhexidine and 3 % glycerol. After this method had been in use for more than a year, a small scale follow-up study was conducted. In particular, those who had dermatological problems in the questionnaire were sampled, and their opinion of the hand washing method sought. Altogether 73 pairs of samples (after soap wash and after disinfection) were taken from 28 persons. Fourteen of them were nurses, 13 auxiliary nurses and one laboratory nurse.

The questionnaire was also distributed to other wards in the hospital using the method adopted for routine hand washing, but no bacteriological samples were taken. Two hundred and seventy seven persons answered the questionnaire.

Statistical methods

One-way analysis of variance was used to test the difference between treatments. The significance of difference between frequencies was tested by using the t test of the mean and t test of the proportions.

RESULTS

Fat removing capacity of the soaps

The mean amount of fat dissolved from the plates by liquid soaps was as follows: soap A, 10·1 %, soap B, 4·5 %; soap C, 3·6 %; soap D, 12·3 %; soap E, 11·4; water (control), 3·9 %.

Table 1. *Mean bacterial counts of the fingers of the staff during the use of the soaps studied*

	Arithmetic mean (S.E.)	Logarithmic mean	Number of samples
Wards 1 and 2			
Soap A	77·8 (7·2)	52·9	223
Soap B	66·4 (6·5)	41·1	252
Soap E	81·5 (8·2)	52·7	310
Wards 3 and 4			
Soap C	82·4 (8·9)	54·5	206
Soap D	74·5 (9·5)	44·6	142
Soap E	68·7 (9·0)	52·1	173

S.E., standard error of the mean.

Laboratory tests with volunteers

When hands were artificially contaminated with *Staph. aureus* or *Pseudomonas*, the latter were found to be more easily removed from the finger tips than *Staph. aureus*. The mean reduction of staphylococci with different soaps varied from 86·5 to 97·6 %. The mean reductions obtained with ordinary bar soap or washing with water only were 83·9 % and 76·7 %, respectively. The difference between treatments was statistically of borderline significance (one-way analysis of variance, $F = 2{\cdot}675$, $P < 0{\cdot}05$). The reduction percentages of *Pseudomonas* were greater than 98 % with all the soaps or washing with water only.

In-use study in wards

Bacterial counts of the fingers

Mean daily logarithmic bacterial counts on the fingers were roughly of the same magnitude during the use of all liquid soaps studied. The arithmetic and logarithmic mean counts were calculated from all the samples for each soap. Those for soap B were slightly lower, and the distribution of the results slightly smaller, than for other soaps (Table 1). The differences were not, however, statistically significant.

The overall mean counts of the nurses were lower than those of the auxiliary nurses (52·8 and 98·0, respectively). Also within these occupational groups, the mean counts for different soaps were virtually the same with the exception of somewhat lower mean counts of auxiliary nurses in ward 1 when soap B was used.

The mean bacterial numbers of 58 % (36/62) of the staff were virtually of the same magnitude for different soaps. Eighteen persons had distinctly higher or lower mean counts for one of the soaps, but these deviations were not constantly higher or lower compared to the mean figures for other soaps. Again for soap B, the mean counts on seven persons were always lower than for other soaps used.

Staph. aureus or gram-negative bacilli were rarely isolated from the hands of the staff during the use of all the soaps (Table 2). After the exclusion of the staphylococcal carriers the differences in the occurrence of *Staph. aureus* were statistically significant in only one conparison (Table 2). Two staphylococcal carriers excluded were permanent carriers, the third one during soap E was a temporary carrier. *Staph. aureus* or gram-negative bacilli were isolated least often during soap C.

Table 2. *Percentage occurrence of* Staph. aureus *or gram-negative bacilli in finger print samples of the staff during the use of the soaps studied*

	% of the samples		
	Staph. aureus	Gram-negative bacilli	Number of samples
Wards 1 and 2			
Soap A	5·8	2·2	223
After exclusion of two staphylococcal carriers	1·0	—	205
Soap B	4·4	4·0	252
After exclusion of two staphylococcal carriers	1·3	—	238
Soap E	9·0	0·3	310
After exclusion of three staphylococcal carriers	2·4	—	285
Wards 3 and 4			
Soap C	2·4	1·5	206
Soap D	6·3	5·6	142
Soap E	6·9	2·9	173

Statistically significant differences between soaps: *Staph. aureus* (wards 3 and 4) soaps C and E, $P < 05$. Gram-negative bacilli (wards 1 and 2) soaps B and E, $P < 0{\cdot}01$; soaps A and E, $P < 0{\cdot}05$; (wards 3 and 4) soaps C and E, $P < 0{\cdot}01$; soaps C and D, $P < 0{\cdot}05$.

Acceptability of the soaps

The results of the questionnaire are presented in Table 3. They suggest better acceptability of soap B compared to other soaps. Despite the small size of the groups, statistically significant differences existed between the soaps (see Table 3). Soap E did not provoke complaints of severe drying or other untoward effects as often as the three other soaps.

Correlation between the questionnaire and the bacteria of the hands

The correlation between the bacterial counts or the presence of pathogenic bacteria on the fingers and the acceptability of soaps was poor. Some persons had high bacterial counts on the fingers, but their opinions did not differ from those of persons who had low bacterial counts. The only evidence suggesting correlation between bacterial counts and the information obtained from the questionnaire was found in 17 members of the staff who had a history of dermatological problems. Seven of these had distinctly lower total mean counts of bacteria on the fingers during soap B than during other soaps.

Continuous use of pine oil soap and alcohol

After prolonged use of pine oil soap and alcohol, the mean bacterial number on the fingers of the staff sampled was 88·4 after washing with soap. After disinfection with 80% ethanol solution the corresponding figure was 33·2. The mean bacterial count of the nurses was 13·7, that of the auxiliary nurses 48·8. After disinfection, only 29% of all the samples showed no growth. The nurses had no bacteria in 52%, and auxiliary nurses in 18% of the samples. After alcohol disinfection, *Staph. aureus* was isolated on three occasions, gram-negative bacilli

Table 3. *Results of the questionnaire: the opinion of the staff on the soaps*

	Wards 1 and 2			Wards 3 and 4		
Soaps	A	B	E	C	D	E
Number of replies	33	34	34	27	27	26
Condition of the skin of the hands						
same as usual	82	85	71	52**	67	85
worse than usual	18	9	21	44**	26	15
better than usual	—	6	9	—	4	—
The soap caused drying of the skin	91	71**	88	92	93	92
Considerably	36	9	15	37	37	12
Moderately or slightly	54	62	74	56	55	81
During the use of soap experienced						
cracking of the skin	30	21	21	41	30	19
redness of the skin immediately after washing	58	32**	50	67	63	54
very often	24	12	12	33	30	12
sometimes	33	21	38	33	33	42
Regarded soap as convenient	33	68	68	41	19**	54
Preferred soap to the previous one	42	74	29	26	56	65
Used hand emollients more than usually	58	15**	35	48	44	38
Decreased the use of soap during the study	21	15	18	19	37*	23

Figures in columns are percentages of respondants to the questionnaire.
*, ** indicate significance of difference between one soap and the others; * denotes $P < 0{\cdot}05$, ** denotes $P < 0{\cdot}01$.

on two occasions. All of these persons reported skin problems and their mean total counts were also high.

Eleven of the 28 persons sampled reported skin problems. Nine of them had used alcohol disinfection either infrequently or not at all, due to skin problems, two admitted avoidance of soap usage. One member of the staff used neither soap nor alcohol for hand washing. None of the persons with healthy skin reported the non-use of soap or alcohol.

According to the questionnaire distributed to hospital wards, dry skin or other skin problems were reported by about half of the staff. Hand creams were used always or occasionally by 96 %. Most of them regarded the hand washing practice adopted for hospital use as 'convenient', or at least had no considerable complaints. Only less than 4 % were not satisfied with the procedure. Six persons (2 %) did not use alcohol disinfection at all, four others used neither soap nor alcohol. Those who washed hands less than 10 times a day used alcohol more often than soap, whereas those who had a high hand washing frequency more often used only soap.

DISCUSSION

In the present study different types of liquid soap were chosen for prolonged use in hospital to investigate their acceptability, the numbers of bacteria on the hands during their use and any possible correlation between these variables. Two of the soaps (A and C) represent soaps commonly used in hospitals. Soaps D and E are byproducts of the wood chemical industry. Soap B is an emulsion based hand disinfectant. The pH of all the soaps, except soap B, was alkaline.

As no official method was found for determining the fat-removing properties of soaps, a laboratory test was designed. Soaps B and C removed less fat than did the others, and not more than water alone. However, this property showed no direct correlation to the acceptability of the soaps. The acceptability no doubt depends on a variety of factors, such as the pH of the soap, composition of fatty acids, individual differences of the skin, etc. and not merely on detergents. On the other hand, *in vitro* experiments may here be misleading as they are too far from reality. For the selection of more acceptable products such a test would, however, be worth developing.

Laboratory tests with volunteers did not reveal great differences in the removal of bacterial contaminants from the hands. Even washing with plain water washed off the bulk of *Staph. aureus* or *Pseudomonas*. A statistically significant difference between soaps might have been obtained with a different test design, but such small differences are hardly relevant in practice.

In the hospital, a cross-over study was first intended, but it proved impossible due to the unacceptability of one of the soaps first given to the wards. Because of this, all the soaps were not used by the same staff and the study design is thus not ideal. Ward 4 is an infant ward which explains the higher hand washing frequency of this ward compared to that of the other wards. However, if one soap actually is superior to others, it should show up also in this kind of study where the wards do not differ much from each other. In hospital studies, the cooperation of the staff is decisive. Difficulties in this respect may distort the results of the entire study. Furthermore, slight statistical differences between products are probably much less important in proper hand hygiene than many other factors, e.g. the hand washing techniques of the staff (Fox, Langner & Wells, 1974; Taylor, 1978*a*, *b*) and the acceptability of the soaps.

The mean total counts of bacteria on the hands were roughly the same during the use of different soaps. No unambiguous difference in favour of any soap at the individual level was found. Suggestive evidence was found for the superiority of soap B, during the use of which lower individual mean counts were recorded more often than with other soaps. During the use of 3 % hexachlorophene emulsion and soap leaflets used earlier in the same wards (Ojajärvi, unpublished) the mean bacterial numbers found on fingers were roughly of the same order as those found during the present study.

The mean finger-print counts of the nurses were lower than those of the auxiliary nurses throughout the study. The auxiliary nurses' hand washing frequency is often slightly higher because of the nature of their work than that of the nurses and they are older than the nurses. In the previous study (Ojajärvi *et al.* 1977) these variables were found to correlate with the failure of a hand disinfectant to reduce the bacterial numbers of the hands. Another possible reason for the difference in the total counts may be found in the more frequent use of alcohol for the hands. The glycerol and other skin caring additives evidently protect the skin from drying and this may then influence the bacterial counts.

The frequency of isolation of pathogenic bacteria for all the soaps studied was fairly low. These bacteria were isolated slightly more often during the use of pine oil soaps. It may be mentioned, keeping in mind the incomparability of different

types of wards even within the same hospital, that these figures are not much higher than those recorded in the study on hand disinfectants (chlorhexidine detergent solution or soap and alcohol) in the neonatal ward (Ojajärvi *et al.* 1977).

The answers to the questionnaire distributed to all the wards after prolonged use of the combination of pine oil soap and alcohol showed that the staff in general were fairly satisfied with the hand washing method used. However, it appeared that the staff did not always use soap or alcohol for hand washing. This finding may partly explain why skin reactions appeared in the study of the neonatal unit (Ojajärvi *et al.* 1977) where hands must definitely be washed before handling babies. In other wards the motivation of the staff for hand washing may not be as strong, since the omission of hand washing is not as obviously disastrous. The untoward effects of different washing agents may therefore be difficult to detect objectively in hospital studies, as the staff may protect their skin by decreasing the hand washing frequency.

The most acceptable liquid soap was soap B, although soap E was not much worse. It was the only emulsion-type hand washing agent in the study. The total bacterial counts of the fingers were slightly lower when this product was used, but the difference between it and other soaps was not statistically significant. Such slight differences may have no practical value in preventing the transmission of hospital pathogens. Nevertheless, it is important that hand washing agents are designed so that their effect on the skin is carefully considered. The staff are reluctant to use preparations which cause skin problems. An acceptable soap motivates hand hygiene by making hand washing pleasant.

Various disinfectants have in field studies been shown to be more effective than soap alone in removing bacterial contamination of the hands (Ayliffe *et al.* 1975; Ojajärvi, 1980). However, the rarity of pathogenic bacteria isolated from the fingers after washing with soap only does not support the routine use of hand disinfectants in all hospital wards. An interesting question remains whether washing the hands with water only would sometimes be enough. In laboratory tests, water alone removed the majority of transient contaminants from the skin. It should be pointed out that the hands were truly washed with water, and not merely rinsed with it.

Detergents may cause skin disturbances in individuals with a sensitive skin or when the frequency of hand washing is high. As alcohol effectively kills microbes, and the combination of soap and alcohol does not seem to add much to their removal (Ojajärvi, 1980), it may be more sensible to encourage the use of alcohol alone instead of always combining it with soap. In addition, the ingredients added to alcoholic solutions to protect the skin also seem to make the skin of the hands tolerate even frequent washing.

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