with 70% and 95% ethyl alcohol a similar though smaller effect was obtained. Previous studies had shown that cursory swabbing of the hands with 70% ethyl alcohol had relatively poor effects (Lowbury and Lilly, 1960). The incorporation of 1% glycerol in alcoholic solutions makes them acceptable to individuals who complain of excessive dryness of the skin after repeated use of alcohol. Aqueous solutions of chlorhexidine applied in the same way as the alcoholic solutions but followed by rinsing and drying of the hands were effective but less so than the alcoholic solutions or alcohol.

Alcoholic solutions rubbed into the skin have been widely used in Germany for disinfecting surgeons' hands (Molitor and Godry, 1972), and there are strong arguments for a more general adoption of this method. An incidental convenience in using alcoholic chlorhexidine for the surgeon's hands is that the same concentrate is used for preparing the solutions commonly used for disinfection of the operation site. There remains a need for detergent cleansing of the hands to remove dirt, blood, and other physical contaminants and probably for the first operation in a list. A "social" wash with soap and water should be adequate for this, but it is probably more convenient to combine the functions of cleansing and disinfection by the use of an antiseptic detergent preparation, such as 4% chlorhexidine detergent solution when a detergent is required. One of our experiments showed chlorhexidine to have greater skin disinfectant activity in isoproyl alcohol than in ethanol, and we found consistently lower viable counts, relative to pretreatment counts, when gloves were worn for three hours before sampling than when samples were taken immediately after disinfection of the hands. This effect could be attributed to residues of antiseptic left on the skin after the use of chlorhexidine, hexachlorophane, or Irgasan DP 300, but some other factor must be responsible in the case of the volatile alcohols, which also showed this effect. The alcohol might marginally damage bacteria, allowing them to recover if inoculated immediately on to culture media but not if left on the skin for three hours before inoculation of the medium. Another possibility is the destruction by drying of some bacteria which survived exposure to alcohol; this effect would be present only in the experiment in which gloves were worn. The self-disinfecting properties of the skin do not seem to be involved as there was no evidence of any reduction in the numbers of bacteria on the skin when gloves were worn after the use of non-antiseptic soap. Clinically, the reduction rather than increase in the bacterial flora of the skin during a three-hour period of wearing surgical gloves was a welcome finding. As such low levels of bacterial flora are maintained during the course of operations it seems unnecessary to disinfect the hands thoroughly before every clean operation in a long list, and three or four treatments on one day with an antiseptic should be quite sufficient for the maintenance of a low equilibrium level of skin flora.

Cleansing the hands with 5-10 ml of 70% ethyl alcohol solution containing 1% glycerol has been considered effective for nurses before they carry out aseptic ward procedures. A study on contamination of nurses' fingers when dressing operation wounds (Noy *et al.*, 1974) showed, by contact plate samplings, that three out of 32 hands (9·4%) carrying pathogens (*Staph. aureus* or coliform bacilli) lost less than 90% of these organisms on washing with soap and water, compared with a similar loss in three out of 47 (6·4%) hands disinfected with alcohol. Ethyl alcohol (70%) was therefore judged to have at least as great an effect in removing these organisms as soap and water. From our studies on the resident flora and from the evidence that *Staph. aureus* is often carried as a resident (Lowbury and Lilly, 1960) ethyl alcohol treatment of nurses' hands may be assumed to have a larger effect than soap and water in reducing the risks of contamination of wounds with staphylococci.

In a preliminary test for acceptance of alcoholic chlorhexidine handwashing by surgeons in operating theatres at this hospital the method was found to be comfortable and convenient. Further trials over a longer period will be required.

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Disinfection of the Skin with Detergent Preparations of Irgasan DP 300 and Other Antiseptics

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Summary

An evaluation of the relative effectiveness of 2% hexachlorophane and 0·75% Irgasan DP 300 bar soaps in disinfection of the hands showed that the former caused a significantly larger reduction in natural skin bacteria than the latter after one handwash and after six handwashings, three on each of two successive days. Repeated use of Irgasan DP 300 bar soap caused a significantly greater reduction in skin flora than repeated handwashings with unmedicated bar soap, but a single handwash gave no significant reduction in skin flora compared with a single use of the unmedicated soap.

In a comparison of a 4% chlorhexidine detergent solution a 3% hexachlorophane detergent crēam and a 2% Irgasan DP 300 detergent solution the 4% chlorhexidine detergent gave the largest mean reduction in skin bacteria after one handwash and after six handwashings and 2% Irgasan DP 300 a poor and erratic reduction after a single handwash. After six handwashings all three preparations gave large

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reductions in skin bacteria. The 2% Irgasan preparation showed some residual activity on the skin after handwashing though less than that with chlorhexidine and with hexachlorophane-chlorocresol detergent preparations.

Introduction

Because of the possible toxic absorption of hexachlorophane from the skin of neonates (Curley *et al.*, 1971) the use of hexachlorophane preparations has been severely restricted and controlled by an order of the Department of Health and Social Security (Statutory Instruments, 1973). Alternative antiseptic soaps and detergent preparations containing 2,4,4'-trichloro-2[1]-hydroxydiphenyl ether (Irgasan DP 300, Geigy), a compound active against Gram-positive cocci and Gram-negative bacilli, have been introduced in place of hexachlorophane, sometimes bearing the trade names—for example, Derl and Cidal—previously used for the hexachlorophane preparations. Evidence of the value of repeated bathing with a bar soap containing 1% of 2,4,4'-trichloro-2[1]-hyroxydiphenyl ether has been reported by Bodey and Rosenbaum (1973).

We report here an assessment of two Irgasan DP 300 preparations compared with other antiseptic detergent preparations used for disinfection of the skin.

Methods

Preparations included in the study were: (*a*) 0·75% Irgasan DP 300 bar soap (New Derl Hospital Soap); (*b*) 2% hexachlorophane bar soap (Medisoap); (*c*) 2% Irgasan DP 300 bactericidal washing cream (Zalclense): the detergent base contains a potassium neutralized vegetable soap, emollients, "pearlising" agents, sequestering and viscosity modifying agents, perfume, and colour; (*d*) 4% chlorhexidine detergent solution (Hibiscrub); (*e*) 3% hexachlorophane detergent cream (Disfex); (*f*) Unmedicated bar soap (control application).

A standard two-minute handwash under running warm water with each of the preparations except 2% Irgasan DP 300 was carried out as described elsewhere (Lowbury and Lilly, 1973). The 2% Irgasan DP 300 cream was rubbed for 30 seconds on to the dry hands, after which rubbing continued with additions of warm water from the tap for one-and-a-half minutes in accordance with the manufacturer's instructions. In a separate study on three subjects 2% Irgasan DP 300 was applied in the same way as the other preparations. To assess disinfecting properties standard bowl sampling tests for viable counts of natural bacteria were made, as described elsewhere (Lowbury and Lilly, 1960), before the first use of the preparation, immediately after the first use, and again after the sixth of a series of handwashes with the preparation, three on one day and three on the next.

Two experiments were made in each of which a Latin square design was used. Neutralizers (1% Lubrol W, 0·5% lecithin, 1% Tween 80, and 1% sodium thiosulphate) were used in the sampling fluid (Ringer's solution) and in the nutrient agar pour plates to prevent the effects of "carry-over" of antiseptic, and tests for carry-over were made on plates showing no bacterial growth or very scanty growth. The methods were identical with those used in earlier studies (Lowbury and Lilly, 1973).

Two experiments were made, one being a comparison of 0·75% Irgasan DP 300 bar soap, 2% hexachlorophane soap, and unmedicated soap and the other a comparison of 2% Irgasan washing cream, 4% chlorhexidine detergent solution, 3% hexachloraphane detergent cream, and unmedicated soap.

Experiments to determine whether active residues of Irgasan DP 300 were left on the skin one hour after washing with the 2% compound were made with inocula of *Staphylococcus aureus* and *Escherichia coli* on the skin (Lowbury and Lilly, 1973).

Results

The comparison of bar soaps containing 2% hexachlorophane, 0·75% Irgasan DP 300, and no antiseptic additive is shown in table I. The hexachlorophane soap gave consistently larger reductions in bacterial counts from skin samplings than Irgasan soap both after a single application and after six applications. Irgasan soap gave a consistently greater reduction in skin samplings than unmedicated soap after six applications. The reduction was greater with Irgasan than with unmedicated soap after one application in all but one of the experimental subjects, but there was a wide variation in the results of a single application and the mean reduction was very small.

A comparison of 2% Irgasan DP 300 cream, 4% chlorhexidine detergent, and 3% hexachlorophane detergent with unmedicated bar soap is shown in table II. The 4% chlorhexidine detergent gave the greatest reduction in bacterial counts from skin samplings both after one application and after six applications. After one application 2% Irgasan cream gave erratic results, and the reductions were consistently smaller than those which were given by either 4% chlorhexidine or 3% hexachlorophane. The cumulative effect of 2% Irgasan cream after six applications was good, the mean percentage reduction being intermediate between that of 4% chlorhexidine (98·1%) and that of 3% hexachlorophane (91·9%).

When 2% Irgasan DP 300 was applied in the same way as chlorhexidine and hexachlorophane preparations a larger and more consistent reduction was obtained after a single hand wash (mean percentage reduction (± S.D.) 57·2 ± 5·5%) than when it was applied as suggested by the manufacturer. After six applications a similar reduction was obtained with either method of application.

TABLE I—*Disinfection of Hands by Various Preparations: Reduction in Bacterial Counts from Hand Washings, expressed as Percentage of Initial Count*

Subjects	2% Hexachlorophane Bar Soap		0·75% Irgasan DP 300 Bar Soap		Unmedicated Bar Soap (Control)	
	After 1 Application	After 6 Applications	After 1 Application	After 6 Applications	After 1 Application	After 6 Applications
1	44·9	97·3	−2·9	54·2	17·2	50·5
2	88·1	97·1	38·3	91·3	22·4	8·7
3	49·1	94·1	19·2	61·7	6·8	37·1
4	42·0	88·9	19·7	21·1	6·0	16·9
5	61·0	78·7	34·2	68·0	13·8	31·0
6	41·7	70·0	16·9	40·7	9·2	14·2
Mean (± S.D.) % reduction	54·5 ± 7·3 (A)	87·7 ± 4·5 (B)	20·9 ± 5·9 (C)	56·2 ± 9·8 (D)	12·6 ± 2·6 (E)	26·4 ± 6·5 (F)

Comparison of treatments:
(A) *v.* (C): $t = 3{\cdot}56$; $P<0{\cdot}01$.
(A) *v.* (E): $t = 5{\cdot}39$; $P<0{\cdot}001$. (B) *v.* (D): $t = 2{\cdot}92$; $P<0{\cdot}02$.
(B) *v.* (F): $t = 7{\cdot}74$; $P<0{\cdot}001$. (D) *v.* (F): $t = 2{\cdot}53$; $P<0{\cdot}05$.
(C) *v.* (E): N.S.

TABLE II—*Disinfection of Hands by Antiseptic Detergent Solutions and Cream: Reduction in Bacterial Counts from Hand Washings, expressed as Percentage of Initial Count*

Subject	2% Irgasan DP 300		4% Chlorhexidine Gluconate		3% Hexachlorophane		Bar Soap (Control)	
	After 1 Application	After 6 Applications	After 1 Application	After 6 Applications	After 1 Application	After 6 Applications	After 1 Application	After 6 Applications
1	51·4	98·5	85·8	99·8	26·7	99·2	24·7	19·2
2	9·0	91·5	81·1	93·5	66·2	91·8	8·2	21·7
3	−42·7	99·1	84·3	99·6	59·5	95·2	22·3	31·5
6	27·0	93·9	97·2	99·7	32·9	81·3	15·4	17·1
Mean (± S.D.) % Reduction	11·2 ± 19·9 (A)	95·8 ± 1·8 (B)	87·1 ± 3·5 (C)	98·2 ± 1·6 (D)	46·3 ± 9·7 (E)	91·9 ± 3·8 (F)	17·7 ± 3·7 (G)	22·4 ± 3·2 (H)

Comparison of treatments:
(A) *v.* (C): $t = 3{\cdot}75$; $P<0{\cdot}01$.
(A) *v.* (E): $t = 1{\cdot}58$ (N.S.).
(A) *v.* (G): $t = 0{\cdot}32$ (N.S.).
(C) *v.* (E): $t = 3{\cdot}95$; $P<0{\cdot}01$.
(C) *v.* (G): $t = 13{\cdot}58$; $P<0{\cdot}001$.
(E) *v.* (G): $t = 2{\cdot}74$; $P<0{\cdot}05$.
(B) *v.* (D): $t = 1{\cdot}0$; (N.S.).
(B) *v.* (F): $t = 0{\cdot}91$; (N.S.)
(B) *v.* (H): $t = 19{\cdot}98$; $P<0{\cdot}001$.
(D) *v.* (F): $t = 5{\cdot}27$; $P<0{\cdot}01$.
(D) *v.* (H): $t = 21{\cdot}4$; $P<0{\cdot}001$.
(F) *v.* (H): $t = 13{\cdot}94$; $P<0{\cdot}001$.

RESIDUAL ACTION

The viable counts of *Staph. aureus* and *E. coli* in samplings from areas of skin previously washed with soap and water (controls) were 54,000/ml and 4,300/ml respectively. From areas previously washed with 2% Irgasan DP 300 *Staph. aureus* counts of 4,250/ml and 2,950/ml and *E. coli* counts of 965/ml and 1,300/ml were obtained. By comparison, areas washed with 4% chlorhexidine detergent before inoculation of bacterial cultures showed mean viable counts of 12·5 and 18·5 *Staph. aureus*/ml compared with 13,500/ml and 19,500/ml from control areas and 0 and 0·25 *E. coli*/ml compared with 900/ml and 1,150/ml on the control areas. A 3% hexachlorophane liquid soap with 0·3% chlorocresol (Ster-Zac) showed a reduction, by these criteria, from 24,250 to 25 *Staph. aureus*/ml washings and from 15,500 to 15 *E. coli*/ml washings (Lowbury and Lilly, 1973). From these results (see also Lowbury *et al.*, 1974) the 2% Irgasan preparation seemed to leave some residual activity after handwashing but less than that obtained with chlorhexidine and hexachlorophane detergent preparations.

Discussion

Both Irgasan DP 300 preparations showed significant skin disinfectant action compared with the inert control, but the effects of a single application were poor and erratic. The bar soap containing 2% hexachlorophane gave considerably better and more consistent skin disinfection than 0·75% Irgasan bar soap after one application or six applications. The 2% Irgasan soap compared favourably with 3% hexachlorophane and 4% chlorhexidine in its cumulative action on repeated use. Probably a bar soap containing 2%, rather than the existing 0·75%, of Irgasan DP 300 would have been more effective than the product which we tested and might have been as effective as the hexachlorophane bar soap.

The disinfectant action of 2% hexachlorophane bar soap after both single and repeated application was better than expected and apparently greater than that of a similar product tested previously (Lowbury *et al.*, 1963). The soap used in this study had been in store for over 12 years, but it seems unlikely that its activity would improve on storage. Hexachlorophane and, to a smaller extent, Irgasan bar soap used in wards might have some value in controlling cross infection. In high risk areas where hand disinfection, including removal of resident flora, is potentially more important, washing with 4% chlorhexidine detergent or a one- to two-minute wash with 10 ml 0·5% chlorhexidine in 95% ethyl alcohol would probably be more appropriate. The 0·5% chlorhexidine in 95% ethyl alcohol has been shown to have greater immediate disinfectant action against skin flora than any antiseptic detergent preparation (Lowbury *et al.*, 1964, 1974). Irgasan DP 300 detergent preparations may have a useful role in place of hexachlorophane for the prophylaxis of the newborn against staphylococcal infection, though its residual activity seems to be smaller than that of hexachlorophane and chlorhexidine detergent preparations.

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