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The mechanism and prevention of cross-infection in dermatological wards

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Much of the extensive work on hospital cross-infection has of necessity been opportunist associated with the occurrence of sporadic outbreaks of infection. Investigations concentrated on such outbreaks cannot give a true picture of the general problem, and the value of any counter-measures which may have been introduced is not easily assessed.

A pilot study, carried out in a large dermatology department, revealed an ideal model for the planned, long-term investigation of hospital infection (Selwyn, 1963). An endemic situation was uncovered in which the extensive skin lesions of in-patients were readily colonized by the abundant pathogenic bacteria present in the environment. Many of the infected patients became in their turn prolific dispersers of pathogens. A detailed study of these processes was facilitated by the long periods of hospital treatment which many patients with skin diseases require. Further work was therefore carried out in this neglected field to investigate the dynamic relationship which exists between the bacterial flora of these patients and that of their environment. The effect of simple anti-bacterial measures upon this relationship was also studied during two of the four stages of the investigation. The principal aim here was to assess the relative importance of nasal carriers and patients with infected lesions in the aetiology of hospital infection.

MATERIALS AND METHODS

Sampling procedures

The investigation was carried out over a 2-year period in three dermatological wards. These are housed in a relatively modern pavilion, within a large teaching hospital. The two main wards, situated on different floors, are 68 ft. long, 28 ft. wide and 12 ft. high; each contains sixteen beds. The third ward, containing eight beds, is 32 ft. long; the width and height are as in the main wards.

The degree of bacterial contamination was measured on two days of the week at representative sites in each ward, and in the adjacent day-room and bathroom. Air counts were performed with pairs of 3·5 in. Petri dishes containing blood agar and 7·5 % salt–milk agar respectively. These were exposed for 2 hr. periods as 'settle plates' and during each period similar plates were exposed in a 'Casella' slit sampler (but this could not be operated in the bathrooms). Solid surfaces were examined by contact-transfer using self-adhesive cellulose tape in a similar manner to that used by Thomas (1961) for swabbing skin. Direct impressions were made from bedding and other fabrics on solid media (Rubbo & Dixson, 1960). Sweepings of settled dust were examined by shaking 100 mg. of dust in 10 ml. of nutrient broth, and carrying out bacterial counts upon the supernatant by the method of Miles & Misra (1938). The fibre composition of the dust was also determined (Pressley, 1958).

From each patient on admission, and at weekly intervals, swabs (moistened in 3·8 % sodium citrate solution) were taken from the anterior nares and from a typical area of the skin lesion. Nasal swabs were plated on to milk agar, free from excess salt, while lesion swabs were plated on to blood agar and salt–milk agar. All swabs were finally incubated in 10 % salt broth. In addition, nasal swabs and hand impressions on milk agar plates were taken regularly from the ward staff.

From all primary cultures on solid media colonies thought to be *Staphylococcus aureus* were subcultured on to nutrient agar and tested for coagulase production. Representative strains were later tested for pigment production on 1 % glycerol monoacetate agar (Willis & Turner, 1962). Bacteriophage typing was carried out upon all coagulase-positive staphylococci, by the methods of Blair & Williams (1961). Phage typing of *Pseudomonas pyocyanea* was performed by the method of Gould & McLeod (1960). Disk-diffusion sensitivity tests were carried out on all the pathogenic bacteria isolated.

Anti-bacterial measures

After an initial period of observation (February to mid-October 1962), anti-bacterial procedures were applied during the second stage (mid-October 1962 to March 1963) in the two main wards. Twice-daily nasal disinfection was introduced in the female ward, using 'Soframycin' nebulizers (1·25 % framycetin and 0·005 % gramicidin). The two adjacent baths were disinfected and cleansed using 1 oz. of concentrated hypochlorite solution mixed with detergent in a gallon of hot water (Boycott, 1956). In the main male ward all skin lesions were treated with 'Rikospray Antibiotic' (neomycin, bacitracin and colistin sulphate), before dressings were applied. During stage III (October to late December 1963), lesions were sprayed in the female ward, while the male ward received no special attention. In the final stage (late December 1963 to May 1964), antibiotic spraying was entirely withheld. Carry-over of anti-bacterial substances was avoided by swabbing immediately before spraying procedures were performed. In addition, when no growth was obtained from both the liquid and solid media, minimal inocula of a sensitive strain of *Staph. aureus* were introduced into the salt broths. Growth occurred in all cases.

RESULTS

Environment

The air. The histograms in Figs. 1–3 show the trends in the air counts of *Staph. aureus*. The busy period between 9 a.m. and 1 p.m. is represented throughout. Total bacterial counts are not shown in the figures: although these counts were usually high, they did not show the marked fluctuations seen in the levels of

Staph. aureus. In the bathrooms *Staph. aureus* constituted over 40 % of the total count on several occasions. Generally, however, it constituted between 2 and 5 % of the total in the wards, bathrooms and day-rooms.

Consistently high counts of *Staph. aureus* were obtained in the small ward, and

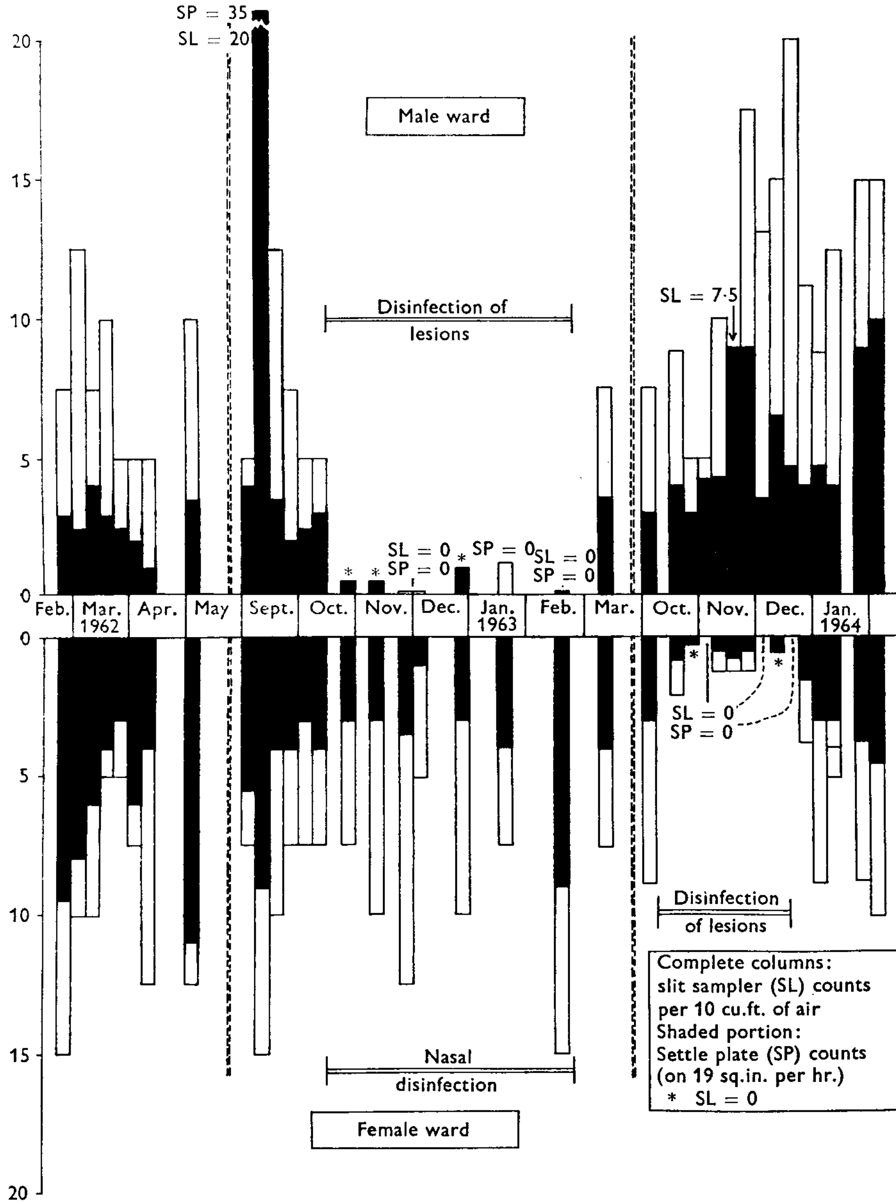

Fig. 1. Mean morning air counts of *Staph. aureus* in the two main wards.

in the male and female wards before mid-October 1962 (stage I), and after December 1963 (stage IV). This is in striking contrast to the levels seen in the male ward during stage II, when the skin lesions were being sprayed, and in the female

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ward during the corresponding period (stage III). Nasal disinfection *per se* produced no significant change (female ward, stage II).

During the course of a day's sampling, large fluctuations were often seen in the counts of individual phage types, especially in the bathrooms. Apart from *Staph. aureus*, coliform bacilli, *Proteus mirabilis*, *Ps. pyocyanea* and non-haemolytic

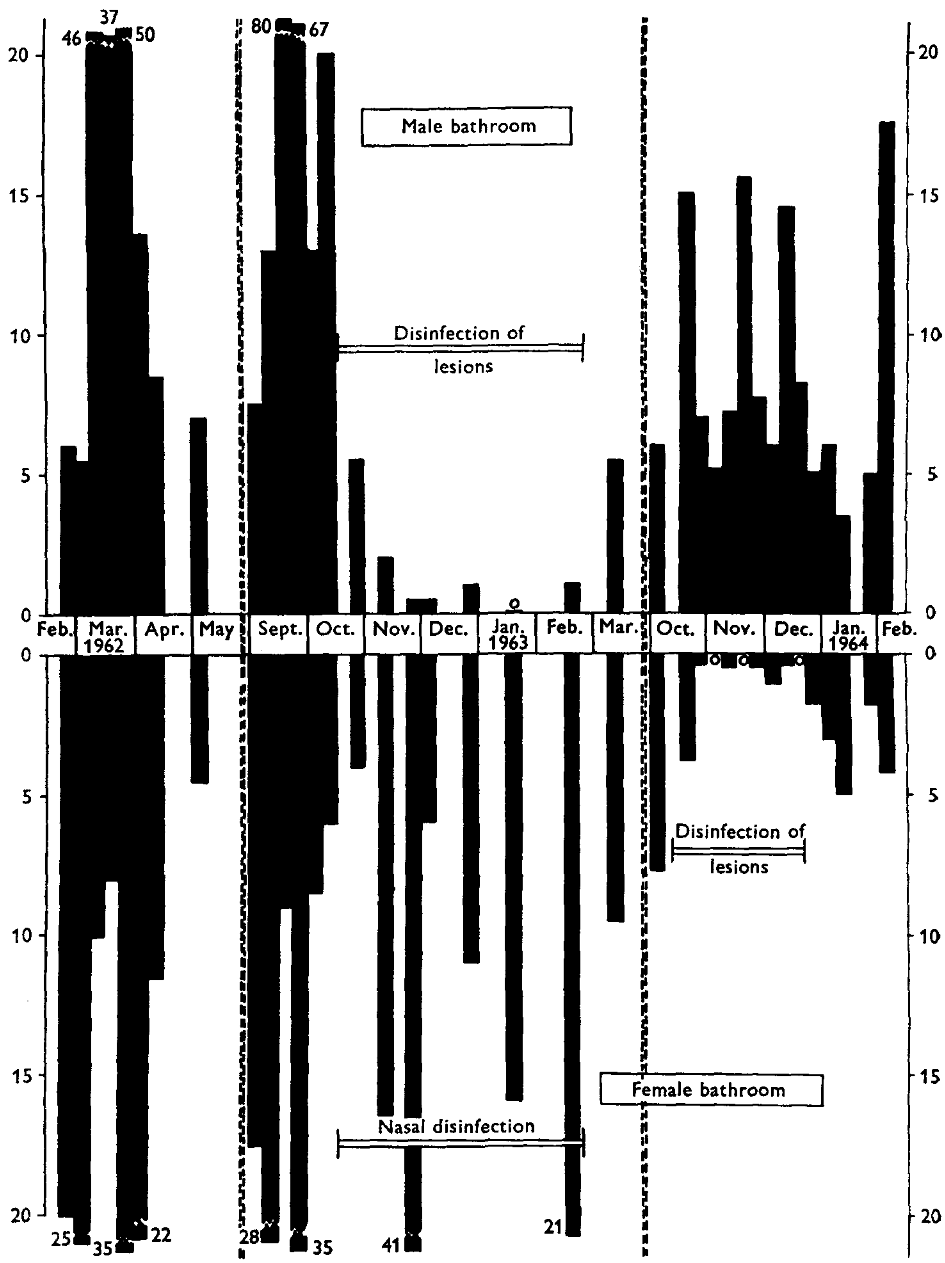

Fig. 2. Mean morning settle-plate counts of *Staph. aureus* in the main bathrooms. (No. of particles falling on 19 sq. in. per hr.)

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streptococci were not infrequently obtained in air samples. The bathrooms again were the most frequent source of these miscellaneous organisms.

The diameters of air-borne particles carrying pathogens were calculated from Petri ratios (Lidwell, 1948), and were found to range widely from 4 μ to over 50 μ. This large scatter was confirmed by direct measurements using a size-grading impaction sampler, as described by Lidwell (1959), although this does not differentiate particles in the heaviest fraction (above about 18 μ in diameter).

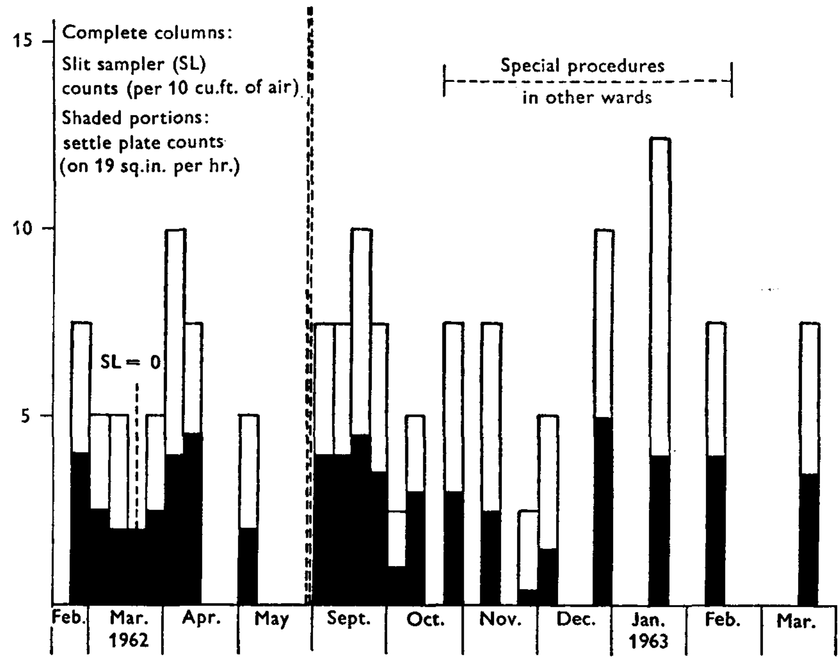

Fig. 3. Mean morning air counts of *Staph. aureus* in the small ward. (Detailed sampling was discontinued after March 1963 as the ward was no longer in normal use.)

The baths. The degree of bacterial contamination of the baths is shown in Table 1. After stage II, the staff in the female ward voluntarily continued to use Boycott's cleansing procedure—but not always adequately. The cleansing of the two male baths was very unsatisfactory throughout the study. Serial samples taken from the baths during the busy period gave clear evidence of a cumulative process of contamination, despite the customary addition of about 30 ml. of cetrimide solution to each patient's bath water. This seemed to exert no bactericidal effect, but might have favoured the Gram-negative bacilli in mixed bacterial populations.

The wards. Bedding, and especially the sheets, usually yielded heavy cultures of the prevalent pathogens—even within a few hours of a change. Almost one-third of the samples yielded strains other than those of the bed occupant. The bedding was, however, free of pathogenic bacteria before use.

Broth washings from many of the samples of settled floor-dust yielded remarkably heavy growths of Gram-negative bacilli, notably of *Ps. pyocyanea* and coliforms (up to 10^4 organisms per ml.); but *Staph. aureus* predominated in more than half of all the samples. Cellulose constituted the great majority of fibres in these samples, though much of the dust was of an amorphous protein nature and produced a strong odour of burning keratin when ignited. Often this debris contained recognizable epidermal scales.

Heavy contamination was usually found, too, on objects as varied as door handles, taps, television sets and dressing trolleys.

Table 1. *Significant cultures of pathogens obtained from the communal baths*

Ward	Stage	No. of tests	Positive cultures* Before cleansing	After cleansing
Male	I	42	—	37 (10)
	II	30	9 (5)	6 (4)
	III	44	36 (5)	22 (4)
	IV	30	25 (4)	14 (0)
Female	I	42	—	35 (8)
	II	30	21 (1)	2 (1)
	III	44	8 (1)	1 (0)
	IV	30	18 (5)	4 (0)

Note. Figures in parentheses refer to numbers of cultures with predominant Gram-negative bacilli.

— = Not done.

* Two or more colonies of *Staph. aureus* or pathogenic Gram-negative bacilli from a 2 sq.in. transfer strip.

Patients

Eczema and psoriasis were the two commonest diagnoses—113 and 114 cases respectively—and the incidence of acquired infection was similar in the two groups (43% and 35% respectively). The clinical significance of infection differed considerably, however, for the infected eczemas could often be diagnosed clinically, whereas most of the psoriasis lesions which yielded heavy cultures of pathogens showed no clinical evidence of infection. The highest incidence of infection with Gram-negative bacilli was found in the third most frequent diagnostic group—the varicose eczemas with ulceration. Of thirty-four such patients, twenty-one acquired infection in hospital, and in twelve of these Gram-negative bacilli predominated.

Tables 2 and 3 summarize the results obtained from lesion and nasal swabs. Only 'moderate' to 'heavy' primary cultures are recorded.

Over the 2-year period the incidence of significant infection in the skin lesions at the time of admission varied between 35% and 60%. Approximately 50% of the patients, however, acquired significant infection whilst in hospital during stages I, III and IV in the male ward, stages I, II and IV in the female ward, and stages I and II in the small ward. Sixty-five of the 129 hospital-acquired infections were due to cross-infection in previously 'clean' lesions; Gram-negative bacilli were responsible for 16% of these. Three-quarters of the remaining acquired infections took the form of super-infections, and 29% were due to Gram-negative bacilli.

Sixteen of the infections acquired in hospital were caused by strains of *Staph. aureus* present in the anterior nares on admission ('autogenous' in Table 2).

Nasal disinfection (female ward, stage II) produced no obvious change in the incidence of cross-infection, although no autogenous infections were seen. In contrast, during stage II (male ward) and stage III (female ward), only two instances of transient, acquired infection were seen. One appeared to be autogenous in a heavy carrier; the other was due to *Pr. mirabilis*.

Table 2. *Pre-existing and hospital-acquired infection in skin lesions*

			No. with infection			
				Acquired in hospital		
Ward	Stage	No. of patients	Upon admission	Primary cross-infection	Super-infection	Auto-genous
Male	I	46	20 (1)	11 (1)	8 (2)	4
	II	37	14	1 (1)	0	0
	III	30	11 (1)	12 (1)	4	1
	IV	37	18*	6	5 (1)	3
Female	I	45	21 (3)	7 (3)	11 (2)	3
	II	44	21 (6)	8 (2)	10 (6)	0
	III	28	13 (4)	0	0	1
	IV	40	17 (3)	12 (1)	3 (2)	2
Small	I	17	6 (1)	4 (1)	2	2
	II	18	11 (2)	4	5 (1)	0

Note. Figures in parentheses refer to numbers of cultures with predominant Gram-negative bacilli.

* Including one case of eczema infected with group A streptococci (*Staph. aureus* predominated in the remaining infections).

Table 3. *Nasal carriage of* Staph. aureus *in patients*

			Nasal carriage		
				Acquired in hospital	
Ward	Stage	No. of patients	Upon admission	Primary infection	Super-infection
Male	I	46	27	5	3
	II	37	17	1	0
	III	30	9	6	0
	IV	37	15	6	3
Female	I	45	26	6	3
	II	44	19	1	0
	III	28	8	0	0
	IV	40	17	6	4
Small	I	17	7	4	1
	II	18	5	3	1

Nasal spraying proved an effective treatment for the established carriers; and, whereas fifty-one out of 233 'uncontrolled' patients became significant carriers after admission, only one patient (aged 82) out of forty-four became a carrier during the period of nasal disinfection. Nevertheless, only one patient out of sixty-five became a nasal carrier during the periods of skin disinfection. Apart from the carriage of *Staph. aureus*, three nasal carriers of *Pr. mirabilis* were seen (one on admission). 'Soframycin' nebulizers were used unsuccessfully by two of these—despite *in vitro* sensitivity of the causative strains. A nasal carrier of *Ps. pyocyanea* was also encountered after admission.

Ward staff

Serial examinations were made of forty-nine members of the staff; twenty-one were persistent nasal carriers. Four became carriers during the study, and two others became transiently super-infected. No other member of the staff carried the prevalent ward strains of *Staph. aureus*. One of the medical staff suffered a severe attack of sycosis barbae (with his own non-prevalent strain of *Staph. aureus*), and a nurse developed subacute paronychia from which *Pr. mirabilis* was isolated (identical with a ward strain prevalent at the time).

The incidence of hand contamination by *Staph. aureus* and Gram-negative bacilli was very high. Nearly 60 % of random hand impressions yielded pathogens during 'uncontrolled' stages of the work. Hand washing was, however, performed with reasonable regularity. The high incidence seemed to reflect rather the heavily vitiated environment in which fresh contamination was readily acquired. During the stages when skin disinfection was performed, very few examinations of hands gave positive results.

Prevalent pathogens

Over the whole 2-year period, three strains of *Staph. aureus* predominated, each of phage group III. One was confined to the male ward, and had the lytic pattern 47/53/75. It was resistant to sulphonamides, penicillin and tetracyclines, but was sensitive to streptomycin, chloramphenicol, erythromycin, methicillin, fusidic acid, neomycin and the related antibiotic, framycetin. One of the two other strains—both endemic in the female ward—was type 7/47/54/75/81 with the same antibiogram as the previous strain except that it was sensitive to penicillin. The third strain was lysed only by group III phages at 1000 times the routine test dilution, and was resistant to sulphonamides, penicillin, streptomycin, tetracyclines and erythromycin. Both penicillin-resistant strains produced yellow pigment (Willis & Turner, 1962); the sensitive strain was cream-coloured. It was interesting to find that the prevalent strain in the male ward became re-established after an apparent absence of 4 months during the period of skin disinfection. One possible source was the skin of a patient who was readmitted after several months with lesions still infected by this particular strain.

Each of the main wards had a predominant strain of *Ps. pyocyanea*. In the female ward representative strains from lesions and the environment were, with two exceptions, of type 'J', and were resistant to sulphonamides, penicillin, tetracyclines, and erythromycin, but only relatively resistant to chloramphenicol

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and streptomycin. In the male ward, type 'M' predominated, and this was resistant to all of the above agents. All strains isolated in this study were sensitive to polymyxin and colistin ('Colomycin').

The differentiation of strains of *Pr. mirabilis* by the technique of Dienes (1946), together with the results of antibiotic sensitivity tests, indicated that several different strains were involved in each of the main wards.

DISCUSSION

The lesions in most dermatological conditions provide a very sensitive indicator of bacterial contamination in the environment. The ease with which infection develops is probably shared only by the comparable lesions of burns (Lowbury, 1960). Thus, 109 of the 233 patients to whom anti-bacterial measures were not applied developed infected lesions after admission to hospital. Primary cross-infection accounted for 53% of the cases, and super-infection for a further 34%. The remaining fifteen cases formed a small but significant group in whom autogenous infection occurred.

Duguid & Wallace (1948), and later workers, have shown the facility which which nasal carriers of *Staph. aureus* contaminate themselves and their surroundings. Amongst patients with skin diseases who are nasal carriers, autogenous infection is probably facilitated in hospital, where the patients lie for relatively long periods in self-contaminated bedding. Access of environmental bacteria to the skin is further assisted both by the considerable periods of complete undressing (before and during ward rounds, and during the twice-daily dressing rounds), and by the wearing of scanty night-attire at all other times.

Nasal disinfection was shown by Gould & Cruickshank (1957) to be effective in preventing staphylococcal skin lesions amongst nasal carriers outside hospital. Stratford, Rubbo, Christie & Dixson (1960) recommended the use of a framycetin nasal spray for the treatment and prevention of nasal carriage in hospital, and the present work confirms the value of this procedure. Its routine use in dermatological practice is justified by a reduction in the incidence of autogenous infections. Nevertheless, nasal disinfection had no effect upon the vicious circle of environmental contamination and cross-infection encountered in this study. The subsidiary part which nasal carriage was shown to play in hospital-acquired infection is in agreement with the findings of Henderson & Williams (1963). They showed in a study of 100 surgical patients that nasal carriers had an incidence of wound sepsis similar to that of non-carriers. These investigators considerably modified their interpretation of earlier work (Williams *et al.* 1962) which had seemed to indicate that nasal carriage—present on admission or acquired in hospital—was an important precursor of wound infection.

The success of skin disinfection in breaking the formidable vicious circle of infection focuses attention upon the central role of infected lesions in the dispersal of pathogenic bacteria. The importance of individual 'dispersers' has recently been shown in three branches of hospital practice. Eichenwald, Kotsevalov & Fasso (1960) detected, in a maternity nursery, 'cloud babies' who contributed large numbers of *Staph. aureus* to their environment when suffering from adenovirus infections of the respiratory tract. Hare & Cooke (1961), and Cooke & Buck (1963) studied small numbers of patients with infected dermatological lesions, and showed that these were responsible for high levels of contamination in their immediate surroundings. Thomas & Griffiths (1961) also obtained their highest air counts of *Staph. aureus* in two small wards devoted to skin diseases. Noble (1962), however, detected in surgical wards, over a 4-year period, only eight dispersers amongst 3675 admissions. The present work provides abundant evidence of the presence of prolific dispersers in dermatological wards, notably with the demonstration of 'broadcasts' of *Staph. aureus* in the bathrooms and wards, together with the high counts of pathogens found in bedding, settled dust, and other situations—especially in the communal baths.

It was shown that these baths, which were used in succession by most of the patients each morning, could be adequately cleansed and disinfected by the method of Boycott (1956). The conditions of the test were particularly exacting in view of the thick greasy applications commonly required in dermatological practice. Because of these dressings, too, the alternative possibility of using showers was not practicable. Another suggestion for countering contamination of baths is to add 1 oz. of 10% hexachlorophene solution (in spirit) to the actual bath water before use (Ayliffe, Alder & Gillespie, 1959). This method was not tried, but, under the difficult conditions described, the similar procedure of adding cetrimide to the water proved valueless (and perhaps even acted selectively for the persistence of *Ps. pyocyanea* and other Gram-negative bacilli).

Despite satisfactory bath hygiene it was disappointing to see no obvious reduction in the incidence of cross-infection (especially with the Gram-negative organisms); evidently numerous additional routes were involved. Thus, surprising reservoirs of Gram-negative bacilli were found in ward dust, indicating frequent, fresh contamination—presumably from the skin lesions of patients. Apart from the heavily contaminated air, further hazards to the patients were provided by the attendants' hands, which gave alarming counts of pathogens—often shortly after washing. Nasal carriage by members of the staff did not, however, seem to be of any importance in the spread of infection. Indeed, it was interesting to find that the staff, in contrast to patients, rarely became carriers of the prevalent pathogens. This finding may be connected with the relatively short duration of exposure to the ward environment.

Recently, convincing evidence has been advanced to suggest that two vehicles are chiefly concerned in dust-borne infection. Rubbo, Pressley, Stratford & Dixson (1960) favour 'fibre nuclei'—fragments of cellulose fibres about 15 μ in diameter. Davies & Noble (1962), working in similar environments, believe that epidermal scales of equivalent size are more important. In the present work cellulose certainly constituted the majority of fibres found in infected dust samples. However, a large part of the dust was composed of keratin material and was often seen to consist of microscopic epidermal fragments. Undoubtedly, both vehicles are involved in a dermatology department, but evidence is at present accumulating to show the importance of epidermal debris in the transmission of infection. Direct measurements in individual skin conditions (to be reported) show that subclinically infected patients, notably those with psoriasis, are particularly dangerous sources of such contaminated debris.

The systematic use of antibiotic sprays on lesions effectively solved the problem of the disperser. The low incidence of nasal carriage observed after skin disinfection might simply have been due to the marked reduction in environmental contamination, but a direct effect on the anterior nares by aerial dissemination—such as Elek & Fleming (1960) produced by spraying methicillin in a ward—cannot be ruled out.

Despite the justification for their use, the potential dangers of such sprays must be considered. In this study neither selection of resistant organisms nor sensitization phenomena in patients were encountered. In view of a recent report from another part of Scotland (Robertson, 1963) a particular watch was kept for signs of the emergence of neomycin resistance in *Staph. aureus*. The use of a mixture of unrelated bactericidal antibiotics in this work undoubtedly militated against the development of neomycin resistance in the prevalent group III strains. The particular antibiotics chosen are—with the exception of colistin—unsuitable for systemic use, and can therefore be reserved for topical application. Colistin is, however, sometimes administered parenterally in the form of the methane sulphonate. Unfortunately the colistin–polymyxin group of antibiotics is the only one presently available which can deal adequately with the ubiquitous *Ps. pyocyanea*. In an attempt to avoid the use of topical antibiotics entirely, tests are now being carried out upon an interesting new agent—'polynoxylin' (Annotation, 1963)—in the form of an aerosol.

During the relevant stages of the present work, all lesions were sprayed. This was because of the high and rising incidence of infection present at the outset. It is not, however, suggested that prophylactic anti-bacterial agents should be used routinely in dermatological conditions; but the early recognition and elimination of clinical or subclinical infection in skin lesions is essential if gross environmental contamination is to be prevented. It is hoped that current work will indicate those patients who constitute the greatest potential hazard in hospital, and who therefore require special attention.

SUMMARY

Over a 2-year period a dermatology department was shown to be a valid model for the long-term study of hospital cross-infection. In the absence of specific anti-bacterial measures, consistently high levels of *Staph. aureus* and Gram-negative bacilli were found throughout the environment. 'Broadcasts' of *Staph. aureus* were particularly evident in the bathrooms, and notable sites of heavy, cumulative contamination were the communal baths, bedding, settled dust, and the hands of the staff.

Cross-infection of lesions occurred in ninety-four of the 233 'uncontrolled' patients—15 cases being due to Gram-negative bacilli. Autogenous infection occurred in another fifteen cases. Nasal carriage of *Staph. aureus* developed in fifty-one patients after admission.

In one of the two main wards nasal disinfection (with 'Soframycin' nebulizers) was used for 4 months, and was effective in the treatment and prevention of nasal carriage; but it produced no change in the level of environmental contamination or in the incidence of cross-infection—even though efficient cleansing of the baths was also instituted. In contrast, during two separate periods of the work disinfection of skin lesions (with 'Rikospray Antibiotic') markedly reduced the counts of pathogens in the environment, and virtually abolished both cross-infection and the development of nasal carriage.

I am grateful to Prof. G. H. Percival and Dr G. A. G. Peterkin for allowing free access to their wards at all times. Dr J. C. Gould kindly carried out phage typing of strains of *Ps. pyocyanea*.

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REFERENCES

Annotation (1963). A new antiseptic. *Lancet*, i, 982.

Ayliffe, G. A. J., Alder, V. G. & Gillespie, W. A. (1959). The disinfection of bath water with hexachlorophane. *Lancet*. ii, 456–8.

Blair, J. E. & Williams, R. E. O. (1961). Phage typing of staphylococci. *Bull. Wld Hlth Org.* **24**, 771–84.

Boycott, J. A. (1956). A note on the disinfection of baths and basins. *Lancet*, ii, 678–9.

Cooke, E. M. & Buck, H. W. (1963). Self-contamination of dermatological patients with *Staphylococcus aureus*. *Brit. J. Derm.* **75**, 21–5.

Davies, R. R. & Noble, W. C. (1962). Dispersal of bacteria on desquamated skin. *Lancet*, ii, 1295–7.

Dienes, L. (1946). Reproductive processes in *Proteus* cultures. *Proc. Soc. exp. Biol., N.Y.*, **63**, 265–70.

Duguid, J. P. & Wallace, A. T. (1948). Air infection with dust liberated from clothing. *Lancet*, ii, 845–9.

Eichenwald, H. F., Kotsevalov, O. & Fasso, L. A. (1960). The 'cloud baby': an example of bacterial-viral interaction. *Amer. J. Dis. Child.* **100**, 161–73.

Elek, S. D. & Fleming, P. C. (1960). A new technique for the control of hospital cross-infection: experience with BRL 1241 in a maternity unit. *Lancet*, ii, 569–72.

Gould, J. C. & Cruickshank, J. D. (1957). Staphylococcal infections in general practice. *Lancet*, ii, 1157–61.

Gould, J. C. & McLeod, J. W. (1960). A study of the use of agglutinating sera and phage lysis in the classification of *Pseudomonas aeruginosa*. *J. Path. Bact.* **79**, 295–311.

Hare, R. & Cooke, E. M. (1961). Self-contamination of patients with staphylococcal infections. *Brit. med. J.* ii, 333–6.

Henderson, R. J., & Williams, R. E. O. (1963). Nasal carriage of staphylococci and post-operative staphylococcal wound infection. *J. clin. Path.* **16**, 452–6.

Lidwell, O. M. (1948). In *Studies in air hygiene. Spec. Rep. Ser. med. Res. Coun., Lond.*, no. 262, pp. 320–33.

Lidwell, O. M. (1959). Impaction sampler for size grading air-borne bacteria-carrying particles. *J. sci. Instrum.* **36**, 3–7.

Lowbury, E. J. L. (1960). Infection of burns. *Brit. med. J.* i, 994–1000.

Miles, A. A. & Misra, S. S. (1938). The estimation of the bactericidal power of the blood. *J. Hyg., Camb.*, **38**, 732–49.

Noble, W. C. (1962). The dispersal of staphylococci in hospital wards. *J. clin. Path.* **15**, 552–8.

Pressley, T. A. (1958). The fibre composition of hospital dust. *Lancet*. ii, 712–13.

Robertson, J. J. (1963). Neomycin resistance in a newly recognised strain of *Staphylococcus aureus*. *Lancet*, ii, 333–4.

Rubbo, S. D. & Dixson, S. (1960). A contact-plate technique for determining bacterial contamination of fabrics. *Lancet*, ii, 394–7.

Rubbo, S. D., Pressley, T. A., Stratford, B. C. & Dixson, S. (1960). Vehicles of transmission of airborne bacteria in hospital wards. *Lancet*, ii, 397–400.

Selwyn, S. (1963). Bacterial infections in a skin department. *Brit. J. Derm.* **75**, 26–8.

Stratford, B., Rubbo, S. D., Christie, R. & Dixson, S. (1960). Treatment of nasal carriers of *Staphylococcus aureus* with framycetin and other antibacterials. *Lancet*, ii, 1225–7.

Thomas, C. G. A. & Griffiths, P. D. (1961). Air-borne staphylococci and the control of cross-infection. *Guy's Hosp. Rep.* **110**, 76–86.

Thomas, M. (1961). The sticky film method of detecting skin staphylococci. *Mon. Bull. Minist. Hlth Lab. Serv.* **20**, 37–40.

Williams, R. E. O., Noble, W. C., Jevons, M. P., Lidwell, O. M., Shooter, R. A., White, R. G., Thom, B. T. & Taylor, G. W. (1962). Isolation for the control of staphylococcal infection in surgical wards. *Brit. med. J.*, ii, 275–82.

Willis, A. T. & Turner, G. C. (1962). Staphylococcal lipolysis and pigmentation. *J. Path. Bact.* **84**, 337–47.