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Comparison of *Staphylococcus aureus* carriage and skin infection rates in hospital and office employees

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SUMMARY

The incidence of *Staphylococcus aureus* in the nose, throat and superficial wound infections of 99 office staff, 129 psychiatry staff and 115 surgical staff was studied over a 4-week period with the purpose of assessing the potential risk to hospital personnel of staphylococcal infection. Incidence rates, both average and cumulative, were essentially similar in the three groups but certain differences in the ecology of the staphylococcal phage groups were observed. Surgical staff appeared to have a more labile pattern of carriage. As in other Scandinavian studies throat carriage rates were high. Staphylococcal carriage seems largely to depend on individual characteristics rather than environmental factors.

INTRODUCTION

The extent of the risk of infection with *Staphylococcus aureus* to which hospital workers are exposed during the course of their work has been widely discussed in Sweden in recent years. From 1 July 1977 staphylococcal skin infection was classified as an occupational disease for insurance purposes although it was unclear whether carriage and infection rates were higher in hospital staff than in groups of workers outside hospital.

Staphylococcal skin infection is common in certain groups of workers, which include, according to the studies of Behrendt (1969) and Caswell *et al.* (1958), hospital workers. Infections in hospital staff may be largely due to faulty techniques or lack of experience, as they tend to occur in hospital orderlies and student nurses (Caswell, 1958).

Nasal carriage rates of *Staph. aureus* have been extensively studied in patients, hospital staff, and normal populations (Williams, 1963; Noble *et al.* 1964; Leedom *et al.* 1965; Noble, Valkenberg & Wolters, 1967; Maxwell *et al.* 1969; Armstrong-Esther & Smith, 1976). The carriage rate in most adult populations at a given time is in the region 30–50% but cumulative rates after several swabbings may

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rise to 90% or more (Williams, 1963; Armstrong-Esther & Smith, 1976). Between 20 and 35% of subjects carry the organism persistently, 30–70% intermittently and up to 20% are non-carriers. The same pattern has been found in hospital personnel, irrespective of the length of employment (Lepper, Jackson & Dowling, 1955; Maxwell *et al.* 1969), although an increasing rate from the beginning of patient contact has also been demonstrated (Rountree & Barbour, 1951).

The frequency of throat carriage of *Staph. aureus* appears to be extremely variable (Williams, 1963), and of possibly more significance than was previously thought, since *Staph. aureus* has been postulated as a cause of sore throat (Christensen *et al.* 1977). The purpose of the present study was to compare the nose and throat carriage rates of *Staph. aureus* and the prevalence of skin infections in two groups of hospital workers and a comparable group of office workers. The opportunity was also taken to examine the antibiotic sensitivity patterns and ecology of the various staphylococcal phage groups in these communities.

MATERIALS AND METHODS

The investigation was carried out between May and June 1977 in Sundsvall, an industrial town in northern Sweden with a population of about 90000. Three groups of subjects were studied: 'surgery', 'psychiatry' and 'office'. The groups were assumed to be of comparable age and sex distribution but at different risk of exposure to *Staph. aureus*. The surgery group comprised a total of 119 staff from nine general surgery and orthopaedic wards together with surgical outpatients department. The wards had 30 beds each and were divided into four-, two- and one-bed units. The psychiatry group comprised a total of 157 staff from 12 geriatric psychiatry wards, each ward having between 20 and 35 beds. In the office group a total staff of 103 persons from the offices of the National Health Insurance Service, the Employment Service and a private insurance company, were examined. Each subject was asked about length of employment, the presence of infections and other illnesses.

Wounds in ward patients and staff judged to be infected by one investigator (U.H.), were cultured by routine bacteriological methods. The anterior nares and tonsillar regions of employees were swabbed at weekly intervals for 4 weeks and plated directly on human blood agar which was incubated at 37 °C for 18–24 h. One presumptive *Staph. aureus* strain from each plate was coagulase tested (Cowan & Steel, 1965), and subsequently phage typed (Blair & Williams, 1961) using the following phages:

Group I 29, 52, 52A, 79, 80, (81),
Group II 3A, 3C, 55, 71,
Group III 6, 42E, 47, 53, 54, 75, 77, 83A, 84, 85, 88, (81),
Miscellaneous 95, 96, 187.

All strains were tested for β-lactamase activity by use of the chromogenic cephalosporin test (O'Callaghan *et al.* 1972) and for sensitivity to antibiotics by the paper

Table 1. *Age and sex distribution*

	Office	Psychiatry	Surgery
No. examined	99	129	115
Mean age	37	38	38
Females	65%	75%	97%
Males	35%	26%	4%
Drop-outs	4	28	4

disk method (Ericsson & Sherris, 1971) using trimethoprim-sulphonamide, doxycycline, gentamicin, erythromycin, phenoxymethyl penicillin, fucidin, streptomycin, chloramphenicol, cephalothin and dicloxacillin (the last by an agar dilution method at 30 °C).

Definitions

Carrier. A person from whose nose or throat *Staph. aureus* was recovered.

Strain. *Staph. aureus* isolate from the same subject with the same phage pattern (or showing not more than one major difference), and the same antibiotic sensitivity pattern.

Sporadic carrier. A person in whom a particular strain was found on only one of the four occasions.

Intermittent carrier. A person from whom the same *Staph. aureus* strain was recovered on two or three of the four occasions.

Constant carrier. A person from whom the same *Staph. aureus* strain was isolated in all four occasions.

RESULTS

As can be seen from Table 1 a total of 343 subjects were examined. Their age and sex distribution is shown together with the numbers of subjects who were rejected because of failure to collect the required number of swabs. Results from the investigation have been analysed in two ways; first with regard to the carriage rates in the three groups of subjects and secondly with regard to the occurrence of individual strains of *Staph. aureus* isolated.

Staphylococcal carriage in office, psychiatry and surgery groups

Carriage rates

Table 2 shows the numbers of non-carriers, sporadic, intermittent and constant carriers in the three groups. The cumulated percentage of all types of carriers after 4 weeks of swabbing was 71%, with no significant difference between the three groups of subjects. The only significant difference displayed is that there were fewer intermittent carriers in the office group than in the other two groups ($\chi^2 = 4{\cdot}3$, $P < 0{\cdot}05$). Two or more strains were commonly isolated from the same subject during the course of the study and in preparing Table 2 only the strain with the highest periodicity has been considered. Table 3 shows that 14% of the

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Table 2. *Numbers of subjects belonging to each of the carriage types (see Definitions)*

	Office group		Psychiatry group		Surgery group		All groups	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Non-carriers	36	(36)	43	(33)	30	(26)	109	(32)
Sporadic carriers	17	(17)	16	(12)	19	(17)	52	(15)
Intermittent carriers	21	(21)	38	(30)	41	(36)	100	(29)
Constant carriers	25	(25)	32	(25)	25	(22)	82	(24)
Total carriers	63	(64)	86	(67)	85	(74)	234	(68)
Total persons examined	99		129		115		343	

Table 3. *Numbers of patients yielding two or more strains of* Staph. aureus *from nose and/or throat over a 4-week period*

	Office group		Psychiatry group		Surgery group		All groups	
	No.	%	No.	%	No.	%	No.	%
	8	(8)	15	(12)	24*	(21)	47	(14)
Total subjects	99		129		115		343	

* Three subjects yielded three strains each.

Table 4. *Percentages of nose and throat swabs yielding* Staph. aureus *over a 4-week period from 343 subjects*

	Office group	Psychiatry group	Surgery group	All groups
Nose Percentage positive	30	34	31	32
Throat Percentage positive	26	29	34	30
Total swabs from each site	396	516	460	1372

total 343 subjects yielded several strains, the proportion being significantly higher in the surgery group (21 %) than in the other groups (10 %) ($\chi^2 = 7{\cdot}5$, $P < 0{\cdot}01$). The percentage of total swabs from nose and throat taken during the 4-week period which yielded *Staph. aureus* is shown in Table 4. It can be seen that throat carriage is almost as common as nasal carriage. On 173 of the 1372 occasions that nose and throat swabs were taken both sites yielded *Staph. aureus*. Fifty per cent of the 60 such pairs from the surgery group yielded different phage types whereas in the other two groups different types occurred together in 15 % of 113 pairs. This difference is highly significant ($\chi^2 = 24{\cdot}2$, $P < 0{\cdot}005$).

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Table 5. *Distribution of phage groups of isolated* Staph. aureus *strains from the personnel groups*

	Office group		Psychiatry group		Surgery group		All groups	
	No.	%	No.	%	No.	%	No.	%
Phage group I	29	(41)	32	(31)	20	(18)	81	(28)
Phage group II	11	(16)	16	(16)	17	(15)	44	(15)
Phage group III	11	(16)	21	(20)	40	(36)	72	(25)
Miscellaneous phage types	3	(4)	13	(13)	19	(17)	35	(12)
Mixed phage types	3	(4)	4	(4)	5	(5)	12	(4)
Non-typable	14	(20)	17	(17)	10	(9)	41	(14)
Total	71		103		111		285	

Superficial staphylococcal infections in staff and patients

In the office group three infected wounds were found, each yielding the same strain as was isolated from the subject's nose or throat. In the psychiatry group two infected wounds were found, both being colonized with strains which appeared simultaneously, or within a week in the subject's nose or throat. Neither of these strains were isolated from patients' wounds. There were three skin infections in the surgery group, one of which was caused by a strain of phage type 96. A strain of this phage type had been isolated from the staff member's nose 2 weeks previously when it had also been recovered from a patient's wound. Another staff member had a skin infection with a non-typable strain that did not appear in her nose or throat. The third infection in this group appeared in a subject colonized in nose and throat with an unrelated strain. The infecting strain did not appear in any patient's wound. In the surgical wards 10 patients had clinical wound infections with *Staph. aureus*. Three of these were of the same phage type as were found in the nose or throat of some of the staff members. In the psychiatry wards 15 patients had clinical *Staph. aureus* infections, mostly in pressure sores. None of these infections preceded nasal colonization of the ward staff with the particular strain. Phage group III strains were more common than group I strains in the surgical ward infections but the reverse was true in the psychiatry wards. This relation was mirrored in the staff nasal colonization rates.

Analysis of the isolated strains

Phage types

Table 5 shows the phage groups of the isolated strains arranged according to the personnel from whom they were isolated. The strains referred to as 'mixed' were susceptible to phages from two groups (9 of 12 were of I+III pattern). Group I strains contributed a significantly larger proportion of the office strains than of the psychiatry and surgery strains ($\chi^2 = 7{\cdot}2$, $P < 0{\cdot}01$), whereas group III strains were significantly more common in the surgery group isolates than in the isolates from other employees ($\chi^2 = 11{\cdot}2$, $P < 0{\cdot}005$). Group II strains were equally represented in the three groups of isolates. The miscellaneous phage types were

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Table 6. *Distribution of phage groups of isolated* Staph. aureus *strains according to frequency and site of their carriage*

	Total no. of strains in each group	Sporadically carried (No.)	Intermittently carried (No.)	Constantly carried (No.)	Site(s) of carriage: Nose (No.)	Throat (No.)	Both sites (No.)
Group I strains	81	16	35	30	28	25	28
Group II strains	44	10	24	10	6	27	11
Group III strains	72	19	32	21	16	40	16
Miscellaneous group strains	35	15	10	10	17	13	5
Mixed strains	12	3	6	3	2	4	6
Non-typable strains	41	16	17	8	11	21	9
Total	285	79	124	82	80	130	75

commoner in the surgery and psychiatry group strains than in the office group strains ($\chi^2 = 14{\cdot}7$, with Yate's correction, $P < 0{\cdot}005$). Table 6 shows the phage groups arranged according to the frequency and site of their carriage. Of the 81 group I strains isolated, 16 (20%) occurred in sporadic carriers against 66 (32%) of the 207 other strains. This difference does not reach significant levels. The miscellaneous and non-typable strains were more commonly carried sporadically (41%) than strains from groups I, II and III (23%) ($\chi^2 = 8{\cdot}8$, $P < 0{\cdot}005$).

β-lactamase production and antibiotic sensitivity

The overall proportion of β-lactamase-producing strains in the study was 66%, the surgery group providing the highest percentage, 71%, followed by psychiatry 66% and office 59%. None of these differences are significant. No significant differences could be detected between the proportion of β-lactamase-producing strains in the phage groups, between the sites of carriage or the types of carrier. Apart from the β-lactamase-producing strains, resistance to antibiotics was extremely rare, one strain from the surgery group showing fucidin resistance. No strains resistant to the isoxyl penicillins or aminoglycosides were detected.

DISCUSSION

In the material presented here, no significant difference between the respiratory tract carrier rates of *Staph. aureus* in the three groups could be 'demonstrated. The mean nasal carriage rate of 32% over the 4 weeks of the survey is similar to that observed by other workers (Noble *et al.* 1967). The throat carriage rate, 30% in this survey, is higher in Scandinavian countries than that observed elsewhere, as remarked by Williams (1963). Christensen *et al.* (1977) observed an increased throat carriage rate to be correlated with symptoms of sore throat in the population they studied, but no sore throats were observed here, despite high carriage rates in all groups.

Certain clear differences emerge with regard to staphylococcal ecology between

the surgery group and the office group, the psychiatry group appearing to lie in an intermediate position. Surgical staff seemed to have a more unstable staphylococcal flora with frequent acquisition and loss of strains. Two or more strains were more often isolated from these subjects during the study period than from other subjects. Personnel from the surgical clinics were more likely to carry one strain in the nose and another in the throat. These differences could possibly be accounted for by the increased exposure of these subjects to a shifting population of patients carrying a variety of different strains of *Staph. aureus*. Although carriage patterns in this group were more complicated than in the other groups the overall carriage rates were almost the same in all groups. As found in other investigations (Leedom *et al.* 1965, Maxwell *et al.* 1969) group III strains were more common in hospital personnel than in people outside hospital, although in this study no difference could be observed in antibiotic sensitivity. Group I strains appeared to be more often 'constantly' carried, more likely to be carried in the nose and more likely to occur in subjects outside hospital.

The incidence of antibiotic resistance in the isolated strains, excepting penicillin, was remarkably low. This can possibly be attributed to the general acceptance of a restrictive antibiotic policy both inside and outside hospital and the relative infrequent use of topical antibiotics.

Wound infections were equally infrequent in all three groups and in only one case could infection in a staff member be connected with an infected patient.

Despite the different ecological patterns of *Staph. aureus* carriage between surgery staff and office staff, carriage rates and wound infection rates appeared equal, thus giving little support to the hypothesis that hospital workers in the wards are in danger of staphylococcal infection because of the environment in which they work. The results indicate rather that staphylococcal carriage is due to individual characteristics (Noble *et al.* 1967). Continued surveillance of hospital associated infections in both staff and patients is necessary, especially in view of the possible different pathogenic potential of certain *Staph. aureus* phage types (Wesley-James & Alder, 1961).

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