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

BY CLAES HENNING, ULLA HILLBORGH, KERSTIN LINDVALL, OLE MARQVARDSEN, JOHN SELLERS AND STAFFAN WAHLIN

*Departments of Clinical Bacteriology and Infectious Diseases, Sundsvall County Hospital, Sundsvall*

*AND ULRIKA RANSJÖ*

*Institute of Clinical Bacteriology, University of Uppsala, Uppsala, Sweden*

*(Received 20 March 1979)*

**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 swabblings may...
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 0, 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*

<table>
<thead>
<tr>
<th></th>
<th>Office</th>
<th>Psychiatry</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. examined</td>
<td>99</td>
<td>129</td>
<td>115</td>
</tr>
<tr>
<td>Mean age</td>
<td>37</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Females</td>
<td>65%</td>
<td>75%</td>
<td>97%</td>
</tr>
<tr>
<td>Males</td>
<td>35%</td>
<td>26%</td>
<td>4%</td>
</tr>
<tr>
<td>Drop-outs</td>
<td>4</td>
<td>28</td>
<td>4</td>
</tr>
</tbody>
</table>

 disk method (Ericsson & Sherris, 1971) using trimethoprim-sulphonamide, doxycycline, gentamicin, erythromycin, phenoxyethyl 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 \( \chi^2 = 4.3, P < 0.05 \). 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
Table 2. *Numbers of subjects belonging to each of the carriage types (see Definitions)*

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

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

<table>
<thead>
<tr>
<th>Carriage Type</th>
<th>Office group</th>
<th>Psychiatry group</th>
<th>Surgery group</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. %</td>
<td>No. %</td>
<td>No. %</td>
<td>No. %</td>
</tr>
<tr>
<td>Total</td>
<td>8 (8)</td>
<td>15 (12)</td>
<td>24* (21)</td>
<td>47 (14)</td>
</tr>
</tbody>
</table>

* 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*

<table>
<thead>
<tr>
<th>Carriage Type</th>
<th>Office group</th>
<th>Psychiatry group</th>
<th>Surgery group</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nose positive</td>
<td>30</td>
<td>34</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>Throat positive</td>
<td>26</td>
<td>29</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>Total swabs</td>
<td>396</td>
<td>516</td>
<td>460</td>
<td>1372</td>
</tr>
</tbody>
</table>

Total 343 subjects yielded several strains, the proportion being significantly higher in the surgery group (21%) than in the other groups (10%) ($\chi^2 = 7.5, P < 0.01$). 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 ($\chi^2 = 24.2, P < 0.005$).
Staph. aureus in hospitals and offices

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

<table>
<thead>
<tr>
<th></th>
<th>Office group</th>
<th>Psychiatry group</th>
<th>Surgery group</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Phage group I</td>
<td>29</td>
<td>(41)</td>
<td>32</td>
<td>(31)</td>
</tr>
<tr>
<td>Phage group II</td>
<td>11</td>
<td>(16)</td>
<td>16</td>
<td>(16)</td>
</tr>
<tr>
<td>Phage group III</td>
<td>11</td>
<td>(16)</td>
<td>21</td>
<td>(20)</td>
</tr>
<tr>
<td>Miscellaneous phage types</td>
<td>3</td>
<td>(4)</td>
<td>13</td>
<td>(13)</td>
</tr>
<tr>
<td>Mixed phage types</td>
<td>3</td>
<td>(4)</td>
<td>4</td>
<td>(4)</td>
</tr>
<tr>
<td>Non-typable</td>
<td>14</td>
<td>(20)</td>
<td>17</td>
<td>(17)</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td></td>
<td>103</td>
<td></td>
</tr>
</tbody>
</table>

**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 ($\chi^2 = 7.2, P < 0.01$), whereas group III strains were significantly more common in the surgery group isolates than in the isolates from other employees ($\chi^2 = 11.2, P < 0.005$). Group II strains were equally represented in the three groups of isolates. The miscellaneous phage types were
Table 6. Distribution of phage groups of isolated Staph. aureus strains according to frequency and site of their carriage

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

The overall proportion of \( \beta \)-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 \( \beta \)-lactamase-producing strains in the phage groups, between the sites of carriage or the types of carrier. Apart from the \( \beta \)-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 staphylo-
coccal 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 staphyloccocal 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).

We are grateful to the staff of Sundsvall sjukhus, Sidsjö sjukhus and the in-
surance and employment offices who gave their willing cooperation. This work was 
supported by a grant from Västernorrlands läns landsting.

REFERENCES

in a healthy non-hospital population of adults and children. Annals of Human Biology 3, 
221–7.

Bulletin 16, 120–32.

World Health Organisation 24, 771–84.

of Nursing 58, 882–3.


