NASAL CARRIERS OF PENICILLIN-RESISTANT STAPHYLOCOCCI IN THE GENERAL POPULATION

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The incidence of sepsis due to penicillin-resistant strains of *Staphylococcus aureus* has increased in recent years, particularly in hospitals and to a less extent in the general population (Elek, 1959). The noses of healthy persons are an important source of pathogenic staphylococci and it has been shown that organisms from the nose may cause sepsis in the same individual (Williams, Jevons, Shooter, Hunter, Girling, Griffiths, and Taylor, 1959).

The nasal carrier rate of *Staph. aureus* in normal adults is between 35 and 50 per cent. (Williams, Blowers, Garrod, and Shooter, 1960). Hospital patients and staff have higher carrier rates than the general population (McFarlan, 1938; Hutchison, Green, and Grimson, 1957), and a large proportion of these carriers harbour penicillin-resistant strains (Barber, Hayhoe, and Whitehead, 1949; Ludlam, 1953; Edmunds, Elias-Jones, Forfar, and Balf, 1955).

McDonald, Miller, Jevons, and Williams (1960) estimated the nasal carrier rate of penicillin-resistant strains of *Staph. aureus* in the general population from a study of Royal Air Force recruits aged 18 to 24 years. However, a further study in the R.A.F. (Miller, McDonald, Jevons, and Williams, 1962) showed that the carrier rate varied with age. The purpose of the present investigation was to find the carrier rates of penicillin-resistant staphylococci at all ages in the general population.

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MATERIALS AND METHODS

The investigation was carried out from August to October, 1960, in three general practices, one in Sandown, Isle of Wight, and two in Lewisham, South-East London. Nose swabs were collected from patients seen either in the surgeries or at home. Whenever possible swabs were also collected from persons accompanying patients at the surgeries, or from other household members present at the time of home visits. If a patient was suffering from sepsis a swab of the lesion was taken before treatment with antibiotics was started.

A card was completed for each person swabbed, recording age and sex, and in Sandown, whether a resident in the area or a visitor and whether from an Urban or Rural District. Each person was also asked: (i) whether there was a baby under 2 years of age in the household, and if so, whether it had been born at home or in hospital; (ii) whether he had been a hospital in-patient, had had a septic lesion, or had been treated with penicillin within the preceding 9 months.

These questions were similar to those asked in the survey of R.A.F. recruits. The recruits with these characteristics had higher than average carrier rates of penicillin-resistant staphylococci.

Nasal and lesion swabs were broken off immediately after collection into bijou bottles of transport medium (Stuart, Toshack, and Patsula, 1954) and posted to reach the laboratory within 48 hours. Swabs were plated on to 1 per cent. serum-agar

medium and incubated overnight at 37°C. Colonies of *Staph. aureus* were tested for coagulase production by the slide method and when necessary by the tube method also.

All coagulase-positive strains of *Staph. aureus* were tested for sensitivity to penicillin. A loopful of an overnight broth-culture was streaked on to a nutrient-agar plate and a filter-paper strip impregnated with penicillin was placed at right angles to the inocula. The strip, measuring 6 by 80 mm., was impregnated by adding 0.34 ml. of a penicillin solution containing 100 units per ml. As a control, the penicillin-sensitive "Oxford" strain and a resistant strain were inoculated on to each test plate. Readings were taken after overnight incubation at 37°C. and any strains less sensitive than the "Oxford" strain but not completely resistant were tested for penicillinase production (Heatley, 1944; Bondi and Dietz, 1944).

Strains found to be resistant to penicillin were tested for sensitivity to tetracycline, streptomycin, chloramphenicol, and erythromycin by "Oxoid Multidisks" with a concentration of 10 µg. antibiotic per disk.

RESULTS

Nasal swabs from 1,165 persons were examined and *Staph. aureus* was isolated from 414 (36 per cent.); 105 (25 per cent.) of the strains were resistant to penicillin. The carrier rate of resistant strains was thus 9 per cent.

94 of the penicillin-resistant strains were tested for sensitivity to other antibiotics; three were resistant to tetracycline only, four to tetracycline and streptomycin, and one to streptomycin and chloramphenicol. No strains were resistant to erythromycin.

The nasal carrier rate of children aged 5 to 14 years was significantly higher than the average (Table I).

TABLE I
NASAL CARRIERS OF *STAPHYLOCOCCUS AUREUS*
BY AGE GROUP

Age (yrs)	Number of Persons Examined	Carriers		Strains Resistant to Penicillin	
		No.	Per cent.	No.	Per cent.
0-4	49	17	35	7	41
5-14	126	66	52*	21	32
15-24	143	50	35	10	20
25-44	338	126	37	30	24
45-64	337	108	32	29	27
65 and Over	172	47	27	8	17
Total	1,165	414	36*	105	25

* Difference 16 per cent.; S.E. of difference 4.7

The proportion of penicillin-resistant strains also differed between age groups, and was significantly higher in persons with one or more of the four

characteristics recorded than in those without them (Table II).

TABLE II
NASAL CARRIERS OF *STAPHYLOCOCCUS AUREUS*
WITH VARIOUS CHARACTERISTICS

Characteristics	Number of Persons Examined	Carriers		Strains Resistant to Penicillin	
		No.	Per cent.	No.	Per cent.
Baby in Household under 2 yrs old	100	48	48	21	44
Hospital In-patient within last 9 mths	96	32	33	14	44
Septic Lesion within last 9 mths	116	55	47	18	33
Treatment with Penicillin within last 9 mths	114	41	36	13	32
Total with Any of These Characteristics	363	148	41	52	35*
Total with None of These Characteristics	802	266	33	53	20*
Total Persons Studied	1,165	414	36	105	25

* Difference 15 per cent.; S.E. of difference 7.5

It was higher, although not significantly so, in persons from Rural Districts than in persons from County Boroughs and Urban Districts (Table III).

TABLE III
NASAL CARRIERS OF *STAPHYLOCOCCUS AUREUS* IN
COUNTY BOROUGH AND URBAN DISTRICTS, AND IN
RURAL DISTRICTS

Type of District	Number of Persons Examined	Carriers		Strains Resistant to Penicillin	
		No.	Per cent.	No.	Per cent.
County Boroughs and Urban Districts	1,031	368	36	90	24*
Rural Districts	134	46	34	15	33*

* Difference 9 per cent.; S.E. of difference 7.3

37 persons had septic lesions and *Staph. aureus* was isolated from 31 of them. Eleven of the strains (36 per cent.) were resistant to penicillin. Twenty of the 37 persons (54 per cent.) were nasal carriers and eight of the carriers (40 per cent.) carried penicillin-resistant strains.

DISCUSSION

25 per cent. of the strains of *Staph. aureus* isolated from the noses of persons in this survey were resistant to penicillin. This is probably a reasonable estimate of the figure for the general population. The proportion was similar in persons living in London and in both visitors to and residents in

Sandown, and was little different when standardized for age and administrative area on the population of England and Wales for 1960 (General Register Office, 1960). In the populations studied, the proportion of persons with one or more of the four characteristics recorded in Table II was probably excessive, but even if they were entirely excluded the rate was reduced by only 5 per cent.

The survey was made from August to October and it is possible that carrier and resistance rates may be different at other times of the year, although other reports have not shown any seasonal fluctuation in the incidence of septic lesions (Gould and Cruikshank, 1957; Miller, 1962).

The high carrier rate of staphylococci in children aged 5 to 14 years conforms to the observations of Hurst (1958) and Masters, Brumfitt, Mendez, and Likar (1958). Hurst (1958) and Williams (1961) showed that the carrier rate of penicillin-resistant strains was high in infants and fell during childhood, and our results suggest that this fall continues into early adult life, and that the level rises in older adults and falls once more in the elderly. These trends are consistent with those found in the R.A.F. The magnitude of the changes suggests that they are real and unlikely to be due to the examination of different cohorts in which the rates are related to different experiences in the past.

A possible sequence of events is that infants are particularly likely to acquire penicillin-resistant staphylococci, but that they generally lose them in adolescence, so that the level reaches a minimum in the late 'teens and early twenties. During adult life, contact with infants and children may lead to a higher rate (Table II), but in old age, when contact with children is less, the rate falls again.

363 persons (31 per cent.) showed one or more of the four special characteristics studied. This proportion is higher than that found in the R.A.F. recruits, probably because most of the persons in this survey were consulting the doctor and therefore more likely to possess one or more of the characteristics.

Persons with a baby in the household or with a history of recent admission to hospital had a significantly higher carrier rate of penicillin-resistant strains than those without the four characteristics studied (Table II). This confirms the findings in the study of R.A.F. recruits. Persons with a history of recent sepsis or penicillin treatment also had higher rates, although the difference was not statistically significant. The different proportions of resistant strains found at different ages was not due to vary-

ing proportions of persons with the four characteristics within the age groups.

As in the recruits, the proportion of resistant strains was higher in persons from Rural Districts than in persons from County Boroughs and Urban Districts (Table III). Although the difference in this survey was not statistically significant, possibly because of the small number of persons from Rural Districts, it was of the same order as that found in recruits, suggesting that a real difference exists. The difference could not be explained in either survey by any difference in age structure or in the possession of one or more of the four characteristics studied.

SUMMARY

Nasal swabs were collected from 1,165 patients and their families in general practices in the Isle of Wight and South-East London. *Staph. aureus* was isolated from 414 (36 per cent.) of them and 105 (25 per cent.) of the strains were resistant to penicillin. Eleven of 36 strains from septic lesions (36 per cent.) were penicillin resistant.

The proportion of resistant strains was higher in children than in adults. It is suggested that variations in the adults may be partly associated with the degree of their contact with infants and young children and with their having been admitted to hospital.

There was some evidence that persons from Rural Districts carried a higher proportion of resistant strains than persons from County Boroughs and Urban Districts.

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