NASAL CARRIAGE OF *STAPHYLOCOCCUS AUREUS* IN A POPULATION OF HEALTHY NIGERIAN STUDENTS

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SUMMARY. The nasal carrier-rate of *Staphylococcus aureus* in 548 Nigerians aged 9–32 years and attending various educational establishments was 56·4%. This rate decreased with increasing age. A significantly greater proportion of females (65·0%) than males (46·5%) were carriers, but the excess in females was apparent only in subjects aged >20 years. Mucoid strains of *S. aureus*, which gave a negative slide-coagulase reaction, were found in 21·5% of carriers aged 10–15 years, but were absent from members of other age-groups. A considerable proportion of all the strains tested were resistant to commonly used antibiotics.

INTRODUCTION

The nasal carriage of *Staphylococcus aureus* is widespread and of considerable epidemiological significance. As shown by Cruickshank (1953), Weinstein (1959), Williams *et al.* (1959) and Daniel (1977), carriers are more prone to skin sepsis and post-operative infection caused by *S. aureus* than are non-carriers. Carriage rates in various populations have been investigated extensively, but most of the work in this field has been done with populations living in temperate environments. There is little information about carriage-rates in the tropics, although the study of Paul *et al.* (1982a) in a Nigerian hospital gave results in broad agreement with those of work done in countries with a temperate climate.

Apart from a few studies, notably those of Millian *et al.* (1960) and Noble *et al.* (1967), staphylococcal carriage has most often been investigated in the patients and staff of hospitals, and little attempt has been made to assess the frequency of factors other than age that might affect its frequency in healthy persons in the general population. Paul *et al.* (1982a) have, however, provided evidence suggesting that occupation had a significant effect on this.

Our preliminary observations on undergraduates suggested that a significantly higher proportion of females than males were nasal carriers of *S. aureus*. We therefore attempted to corroborate these initial findings and extended the study to children.

MATERIAL AND METHODS

Subjects. These were all in good health and comprised: 80 primary-school pupils in Class VI at the Staff School, whose ages ranged between 9 and 12 years; 169 students at Moremi High

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School in Forms I to IV, aged 10 to 18 years; and 299 University of Ife students aged 15–32 years, of whom 133 were third-year Pharmacy students and the rest from the general student population but with a preponderance of pre-clinical medical students. Almost all of the subjects were Nigerian or of other African descent.

Both the Staff School and Moremi High School are non-residential. They are situated on the campus of the University of Ife and cater mainly for children of members of its staff.

Specimen collection and isolation procedures. Swabs were collected during school hours from the right anterior nares by techniques described by Cameron (1970) and inoculated on to plates of blood agar (Blood Agar Base, Oxoid, code CM271, plus time-expired human blood, 5% v/v) and Mannitol Salt Agar (Oxoid, code CM85) as previously outlined (Paul *et al.*, 1982b). After overnight incubation, colonies suspected of being staphylococci were checked by gram-stained smears when indicated, and tested for coagulase production by the slide technique (Cadness-Graves *et al.*, 1943) and, if negative, by the tube technique (Williams and Harper, 1946). Selected strains were examined for the presence of capsules by the India ink method.

Tests for antimicrobial sensitivity. In general, the method of Bailey and Scott (1970) was followed. The surface of five isolated and typical colonies of *S. aureus* were touched with a straight wire and the inoculum was transferred to a plate of Diagnostic Sensitivity Medium (Oxoid, code CM261) and spread by streaking successively in three directions with a cotton swab (Stokes, 1975). A Multidisc (Oxoid) bearing the following quantities of antibiotics: penicillin G, 1.5 units; ampicillin, 2 µg; methicillin, 5 µg; streptomycin, 10 µg; tetracycline, 10 µg; chloramphenicol, 10 µg; co-trimoxazole, 25 µg; and erythromycin, 10 µg was applied to the surface of the medium and the plate was incubated overnight. Antimicrobial sensitivity was determined by comparison with the table of zone sizes provided by the manufacturer of the Multodiscs.

RESULTS

Carriers

In all, more than half of the subjects (56.4%) harboured *S. aureus* in their anterior nares (table I), with a significantly greater proportion of female carriers (65.0%) than male (46.5%) ($\chi^2=18.24$, $p<0.001$). Table II shows that, although there was a tendency for the carrier-rate for all students to fall with increasing age, this effect was mainly attributable to the results given by the males. The higher frequency of carriage in females than in males was confined to the older age-groups (18–32 years) ($\chi^2=16.17$, $p<0.001$), and between 9 and 17 years there was no difference in the carrier-rates for the two sexes ($p>0.95$).

Mucoid strains of S. aureus

In the course of the investigation, mucoid staphylococcal colonies were observed with considerable frequency in the younger subjects (table III). In all, they were isolated from 35 persons and were confirmed as staphylococci by Gram's stain; 34 of them gave a negative slide-coagulase reaction but all 35 clotted plasma within 1 h in the tube test. The one strain that gave a positive slide test proved to be a mixture of "normal" and mucoid staphylococci. Two mucoid strains were examined by the India-ink method and showed the presence of capsules.

Mucoid strains of *S. aureus* were isolated with greatest frequency in subjects aged 11–12 years, among whom nearly one-third of all *S. aureus* carriers harboured a mucoid strain. Their frequency was less in younger and older persons, and none was found in 140 carriers aged > 15 years. Mucoid strains were isolated from students in both the Staff School and the Moremi High School, and the carriers of these strains

TABLE I
Nasal carriage of S. aureus by male and female students

Source	Number of persons yielding <i>S. aureus</i> /number examined (and percentage) among		
	males	females	all students
<i>Schools:</i>			
Staff School	29/32 (90.6)	39/48 (81.3)	69/80 (85.0)
Moremi High School	34/59 (57.6)	75/110 (68.2)	109/169 (64.5)
<i>University:</i>			
Pharmacy students	19/63 (30.2)	38/70 (54.3)	57/133 (42.9)
Others	36/100 (36.0)	39/66 (59.1)	75/166 (45.2)
Total	118/254 (46.5)	191/294 (65.0)	309/548 (56.4)

TABLE II
Relation of S. aureus carriage to age and sex

Age (years)	Number of persons yielding <i>S. aureus</i> /number examined (and percentage) among		
	males	females	all students
9-11	32/37 (86.5)	60/76 (78.9)	92/113 (81.4)
12-14	23/36 (63.9)	49/72 (68.1)	72/108 (66.7)
15-17	8/17 (47.1)	6/14 (42.9)	14/31 (45.2)
18-20	21/42 (50.0)	40/68 (58.8)	61/110 (55.5)
21-23	21/75 (28.0)	31/53 (58.5)	52/128 (40.6)
24-32	13/47 (27.7)	5/11 (45.5)	18/58 (31.0)
Total	118/254 (46.5)	191/294 (65.0)	309/548 (56.4)

TABLE III
Frequency of mucoid strains of S. aureus in carriers of various ages

Age (years)	Number of mucoid/total strains (and percentage) among		
	males	females	all students
9	0/0	0/6	0/6 (0)
10	1/18	6/32	7/50 (14.0)
11	4/14	8/22	12/36 (33.3)
12	3/7	8/28	11/35 (31.4)
13	2/9	1/9	3/18 (16.7)
14	0/7	1/12	1/19 (5.3)
15	0/1	1/4	1/5 (20.0)
16-32	0/62	0/78	0/140 (0)
Total	10/118 (8.5)	25/191 (13.1)	35/309 (11.3)

were not associated through family relationships or locality of residence. Although a higher proportion of mucoid staphylococcal colonies was obtained from females than males, this difference was not significant.

Relation of nasal carriage to family size and residential room-occupancy

For students who attended the Staff School or the Moremi High School, there was no difference in the carrier rate between persons belonging to families (including

parents) of three to six and those who belonged to families of seven and more individuals ($\chi^2=0.30$, $p>0.5$) (table IV).

Likewise, the carriage rates of *S. aureus* among university students were similar for students accommodated one to six per room and for those who occupied rooms shared by six or more other students ($\chi^2=0.06$, $p>0.5$) (table V).

Antimicrobial sensitivity patterns

A total of 167 of the 177 strains (94.4%) of *S. aureus* isolated from primary and secondary school-children were tested for their antimicrobial sensitivity patterns. The percentages of strains resistant to individual agents were as follows: penicillin G, 94.0; tetracycline, 31.1; chloramphenicol, 14.4; streptomycin, 10.2; erythromycin, 1.2; methicillin, 0.4; co-trimoxazole, 0. The mucoid strains were, like the rest, most commonly resistant only to penicillin (27 of 33 tested; 81.8%). Of the remaining six strains, five were resistant to penicillin and tetracycline and one was sensitive to all the agents.

TABLE IV
Nasal carriage in school pupils of S. aureus in relation to family size

Number in family*	Number of persons yielding <i>S. aureus</i> /number examined (and percentage) among		
	males	females	all pupils
3-4	1/3 (33.3)	12/17 (70.6)	13/20 (65.0)
5-6	24/34 (70.6)	48/67 (71.6)	72/101 (71.3)
7-8	28/41 (68.3)	44/57 (77.2)	72/98 (73.5)
9-10	7/7 (100.0)	4/6 (66.7)	11/13 (84.6)
11 & over	3/6 (50.0)	6/7 (85.7)	9/13 (69.2)

* Including parents.

TABLE V
Nasal carriage of S. aureus in relation to number of co-occupants per residential room in university (pharmacy) students

Number of occupants	Number of persons yielding <i>S. aureus</i> /examined (and percentage) among		
	males	females	all students
1-4	1/6 (16.7)	2/3 (66.7)	3/9 (33.3)
5-6	6/14 (42.9)	8/14 (57.1)	14/28 (50.0)
7-8	6/16 (37.5)	26/47 (55.3)	32/63 (50.8)
9-10	3/20 (15.0)	2/5 (40.0)	5/25 (20.0)
11-14	3/7 (42.9)	0/1 (0)	3/8 (37.5)

DISCUSSION

The results of this study, as with several others (see Williams, 1963), show that age is an important determinant of the rate of nasal carriage of *S. aureus* in the sample population used. The percentage of subjects carrying *S. aureus* varied from 81.4% in

the 9–11 years age group to 31·0% in the 14–32 years age group with a progressive decrease as the age increased from 9–32 years.

We observed a significant difference between the rate of carriage by female (65%) and male (46·5%) subjects. Such a difference has not been reported by other workers (e.g., Noble *et al.*, 1967) but Millian *et al.* (1960) in the USA reported that 20% of the 87 black females and 10% of the 72 black males in their sample carried coagulase-positive staphylococci. No such disparity in carriage rates was however observed with white males and females in the same study. In the age-groups we sampled, the difference between males and females was confined to subjects aged over 20 years.

Most studies in this field have been performed in temperate countries amongst a predominantly white population. The few carried out in the tropics have reported that there is a low frequency of nasal *S. aureus* carriage in non-whites (Findlay and Abrahams, 1946; Rountree, 1956). Millian *et al.* (1960) have also reported that in a study of adults in the USA the frequency of nasal carriage amongst blacks was very low and was significantly lower in blacks than whites. The findings of Noble (1974), who examined black and white school-children aged 5–14 years in London, were similar. Our study of black children and young adults in Nigeria gave very different results, in that roughly 50% of the subjects sampled were found to be carriers. This figure falls within the range described by Williams (1963) as being normal for populations living in temperate zones. Factors other than racial characteristics may therefore be responsible for the low carriage rates that were previously reported for blacks.

An interesting feature of our findings was the frequent isolation of mucoid strains of *S. aureus* from students aged 10–14 years and their absence from subjects aged > 15 years. The carriers of these strains came from both of the schools sampled; this suggests that the carriage of mucoid strains is connected with the age of the subject. There is little information about the distribution of mucoid strains in the nares of healthy persons and its significance. The subject merits further investigation.

One important aspect of the epidemiological study of *S. aureus* concerns its ability to spread through populations. It might be expected that overcrowded conditions would enhance its spread. Our observations do not, however, support this because the number of people with whom the subjects shared a room did not seem to affect the rate of nasal carriage. Staphylococci are relatively resistant to drying and would therefore remain viable for long periods on articles of dress and furniture. Contact with such articles might be a more important means of spread than contact with carriers. Our results showed that females undergraduates were more likely to be carriers than their male counterparts even though the males tended to live in a more densely populated environment. On the whole, however, the females lived in rooms which contained more items of furniture, clothes and other such artefacts than rooms inhabited by males; the higher rate of female carriage might be related to this. On the other hand, black females may have a greater intrinsic disposition to be carriers of *S. aureus* than black males (Millian, 1960).

The sensitivity patterns showed that virtually all the organisms tested (94·0%) were resistant to penicillin. This is probably related to the wide use of this agent because, as pointed out by Bulger and Sherris (1968), the level of resistance to any antibiotic substance is proportional to the level of its use. Up to 30% of organisms tested were found to be resistant to tetracycline. This is a very high figure for a non-hospital population, especially since tetracycline resistance has been used to identify hospital

strains of *S. aureus* in Britain (Lowbury and Ayliffe, 1974). It is however lower than the figures obtained in an earlier Nigerian study (Paul *et al.*, 1982a). This difference may be related to a lower usage of tetracycline in the children we examined than in the general population sampled in the earlier study. It is however still apparent that there is need to control the use of antibiotics in our population.

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