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CLINICAL RESEARCH

Prevalence and Risk Factors of *Staphylococcus Aureus* Nasal Carriage among Healthy Children in Nsukka Local Government Area of Enugu State, Nigeria: A Comparative Study

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ABSTRACT

BACKGROUND

Staphylococcus aureus can asymptomatically colonize the anterior nares, skin and other body sites but the anterior nares of the nose are the most frequently colonized site.

OBJECTIVE

The main objective of this study was to determine the nasal carriage rate, and the associated risk factors of *S. aureus* among urban and rural school children in Nsukka Local Government Area of Enugu State.

METHODS

This study was a community based comparative cross-sectional study conducted on 520 healthy children. Social-demographic data were collected using questionnaires, whereas nasal samples were collected from the anterior nares of children using sterile swab sticks moistened with sterile normal saline. The samples were cultured on mannitol salt agar and blood agar and incubated for 24 hours to 48 hours at 37°C. *S. aureus* was identified by growth and colony characteristics on these media and was confirmed by standard biochemical methods.

RESULTS

This study revealed high prevalence of S. aureus among children. Of the 520 children examined, the overall nasal carriage rate was 42.7% (222/520); of which 55.4% (123/222) were males whereas 44.6% (99/222) were females.

Overall carriage rate of S. aureus in the urban school was 23.1% (120/520) as compared to rural schools with prevalence of 19.6% (102/520). Sex (p-value = 0.006), family size (p-value = 0.004), and number of children per classroom (p-value = 0.011), were significantly associated with and risk factors for *S. aureus* carriage.

CONCLUSION

There was high prevalence of *S. aureus* among children in this study area with gender, family size and number of children per classroom being risk factors.

KEYWORDS

Staphylococcus aureus; Prevalence; Nasal carriage; Risk factor

INTRODUCTION

Staphylococcus aureus is cluster-forming, non-motile, non-spore forming, facultative, aerobic, Gram-positive cocci. *Staphylococcus aureus* is pathogen of humans, causing a wide range of infections ranging from minor skin infections and abscesses to life-threatening diseases such as pneumonia, meningitis, endocarditic, food poisoning, toxic shock syndrome and septicaemia which may be rapidly fatal [1]. On the other hand, they are also normal flora of humans, very well adapted to colonize the human skin and mucosa and our bodies probably provide some major niches for the species. Although other body sites are colonized, anterior nares are the most frequent site of colonization by *S. aureus*. We are always exposed to bacteria including *S. aureus*, but still only some people are carriers over a longer period of time than others. Carriage is asymptomatic and not harmful to the host and even to some extent protect the host from infection by other bacteria [2,3]. Genetic evidence suggests a causal relationship between nasal *S. aureus* and subsequent invasive *staphylococcus aureus* thereby putting carriers at the risk of autoinfection most especially during hospitalization and major surgery or when the carrier is immunocompromised [2,4-6].

S. aureus colonizes the anterior nares of 20% to 80% of the humans [7]. Its carriage pattern can either be persistent or intermittent. About 20% to 30% of healthy individuals are persistent nasal carriers of *S. aureus* whereas approximately 30% are transient or intermittent carriers [8,9]. With the help of some proteins and cell surface molecules, *S. aureus* can bind to the nasal epithelial cells and become a persistent carriage [10]. When individual is tested for nasal carriage of *S. aureus* at two different time point (two weeks interval), carriage state can be defined as persistent when individual tested positive for *S. aureus* at the two different time point and as transient or intermittent when the individual tested positive for *S. aureus* at only one time point and not both [11].

Knowledge of the prevalence of such nasal *Staphylococcus aureus* among healthy school children in Nsukka Local Government Area (LGA) of Enugu State is lacking. The aim of the study was to evaluate the nasal carriage rate, and associated risk factors of *S. aureus* among healthy school children in both rural and urban region of Nsukka L.G.A. of Enugu state, Nigeria.

METHODS

Study Area and Subjects

This study was conducted in ten schools distributed in the urban and rural communities in Nsukka LGA of Enugu State, Nigeria. Five of the schools (two primary and three secondary schools) were randomly selected from

Nsukka urban. Equally, five schools (three primaries and two secondary) were randomly selected from the rural communities in Nsukka LGA. The study was conducted on children population within the age range of 5 years - 18 years in the randomly selected schools. During this cross-sectional study 520 healthy school children were examined for nasal carriage of *S. aureus*.

Study Design and Period of Study

The study had a cross-sectional design; a community-based comparative cross-sectional study conducted from September 15, 2021 to March 15, 2022.

Inclusion and Exclusion Criteria

Inclusion criteria

The inclusion criteria were: Healthy school children from recruited schools who showed willingness to participate in the study; children that gave us their socio-demographic information through our questionnaire; children who were not sick or on any antibiotic therapy at the time of sample collections were included in this study.

Exclusion criteria

The exclusion criteria were: Children who were sick; those who could not give us their socio-demographic data; those who were not available for nasal swab collection; those who later refuse to participate in the study due to some reasons (the non-response participants) and children who were on antibiotic therapy at the time of the sample collections were excluded from this study.

Sample Size Determination and Sampling Technique

Single population proportion formula (Coachrans sample size formula) was used to determine the sample size that would represent the entire population of children in the study area. The sample size was estimated by considering a 56.3% local prevalence of *S. aureus* nasal colonization [12], 5% precision level (margin of errors), and confident interval of 95%. A minimum sample size of 378 was calculated using this formula. However, adding the 10% non-response rate and design effect of 1.25, the final sample size was estimated to be 520. Using a simple random sampling technique, ten schools were selected from all the schools in Nsukka LGA of Enugu state. The number of study participants in each school and their classes was proportionate to school and class sampling frame or population and each study participants in a class was also selected by simple random sampling.

Ethical Consideration

Ethical clearance was obtained from Faculty Research Ethics Committee, Faculty of Pharmaceutical Sciences, University of Nigeria Nsukka, with reference number FPSRE/UNN/21/00009 on June 23rd, 2021. Letter of permissions for sample collection from the children were obtained from the head of each school (principal, headmaster or mistress) prior to the day of sample collection. The participants were enrolled only after they were sufficiently counseled, and their informed consent obtained either directly from them or from their parents/guardians. Relevant confidentiality was maintained for schools and for every study participant.

Data Collection

Collection of socio-demographic data

A questionnaire based on assumed or suspected risk factors for *S. aureus* nasal carriage was developed. This self-administered questionnaire was developed in line with the objectives of the study and was used to collect socio-demographic data of each subject. The socio-demographic data collected includes: Age, gender, family size, residence, number of children in the class, living with health-care worker, educational level, history of surgery, history of having chronic disease, history of having skin infection, use of antibiotics in the last month, history of hospitalization and visit to the hospital/clinic.

Collection and culturing of nasal sample

Samples were obtained from each child from both anterior nares. Sterilized cotton swab moistened in sterile normal saline was introduced 2 cm - 3 cm into the nasal cavity and rotated 4 times - 5 times both in clockwise and anticlockwise directions before withdrawal. Each sample swab was streaked immediately on mannitol salt agar and was labeled appropriately. The samples were taken to the Microbiology Laboratory of Pharmacy Technician Department, Eucharistic Heart College of Health Technology, Orba, Nsukka within two hours of collection for incubation at 37°C for 24 hours - 48 hours. A total of 520 samples were collected from the children.

Isolation and Identification of Staphylococcus Aureus

Nasal swab samples that showed growth of bacteria on mannitol salt agar plate with yellow background and yellow colonies of bacteria were collected and streaked on the previously prepared plate of blood agar and incubated at 35°C for 24 hours - 48 hours. Isolate that produced beta-haemolysis on blood agar was selected and sub-cultured onto nutrient agar and Gram-stained.

Gram-positive cocci in cluster were subjected to standard biochemical method such as catalase test, coagulase (slide and tube) test, and deoxyribonuclease test. Bacteria growth on MSA, that fermented mannitol with its characteristic golden yellow color, showed beta-haemolysis when cultured on blood agar, Gram positive cocci in cluster, catalase positive, coagulase positive and deoxyribonuclease positive were confirmed to be *S. aureus*.

Data Analysis

The socio-demographic data and experimental findings on each child with unique identity number were entered into Excel spreadsheet to check the correctness of the raw data and then transferred to statistical package for social sciences (SPSS) version 16 for analysis. Contingency tables were employed to check the distribution of *S. aureus* between categorical variables. Association between these categorical variables and *S. aureus* was investigated using chi square and fisher exalt test. Tests were 2-tailed and alpha level of 0.05 indicated as statistically significant results. Categorical variables were expressed as number (N) and percentages (%) and continuous variable such as age was expressed as mean ± standard deviation.

RESULTS

Result of Socio-Demographic Characteristics of Participants

In both urban and rural schools combined, a total of 520 subjects participated in this study. The male children accounted for 48.5% (252/520), while the female constituted 51.5% (268/520) of the total participants. The ages of the study participants ranged from 5 years - 18 years with a mean age of 11.4 years (±3.5). Out of the total number of children involved in this study, 52.3% (272/520) were between the ages of 5 years - 11 years; 45.8% (238/520) had their ages in the range of 12 years - 17 years, whereas 1.9% (10/520) had their ages above 17 years.

Fifty four percent (54%, 281/520) of these children resided in the urban area while 46% (239/520) lived in the rural settings. More than half of the participated children had a family size of between 5 members - 7 members, 66.2% (344/520) while 31.3% (163/520) lived in families with less than or equal to four members. A very small proportion of the study participants, 2.5% (13/520), had family size greater than seven members. The proportion of participants in primary schools was 51.9% (270/520), whereas the proportion in secondary schools was 48.1% (250/520). Most of these children, 81.1% (422/520), were in classrooms that contained 10 children - 30 children; 13.7% (71/520) where in the classroom that contained 31 children - 50 children whereas 5.2% (27/520) belonged to a classroom that contained more than 50 children. Almost all the children did not use antibiotics in the last one month prior to this study, 86.3% (449/520), whereas only 13.7% (71/520) used antibiotics in the last one month prior to the study. Besides that, 82.9% (431/520), had no history of hospitalization in the past three months prior to this study and about one-third, 28.7% (149/520), had no history of visit to the hospital/clinic; 98.3% (511/520) had no history of surgery; 88.7% (461/520) had no history of contact with health-care worker; 97.3% (506/520) had no history of chronic disease and/or infection as at the time that this study was carried out (Table 3).

Table 1: Frequency distribution of subjects on socio-demographic characteristics.

		Frequency	Percentage
Study Characteristics		**N = 520**	**(%)**
Age	5 – 11	272	52.3
	12 – 17	238	45.8
	> 17	10	1.9
Sex	Male	252	48.5
	Female	268	51.5
Residence	Urban	281	54
	Rural	239	46
Family Size: Number of Family Members Living with Participant	≤4	162	31.2
	5 – 7	344	66.3
	> 7	13	2.5
Educational Level	Primary	270	51.9
	Secondary	250	48.1
Number of Children in Classroom	10 – 30	422	81.2
	31 - 50	71	13.7
	> 50	27	5.2
Use of Antibiotics in the Last One Month	Yes	71	13.7
	No	449	86.3
History of Hospitalization	Yes	89	17.1
	No	431	82.9
Visit to Hospital/Clinic in the Last One Month	Yes	105	20.2
	No	415	79.8
History of Surgery	Yes	9	1.7
	No	511	98.3
living with a Health Care Worker	Yes	59	11.3
	No	461	88.7
History of having Chronic Disease	Yes	14	2.7
	No	506	97.3

Nasal Carriage of Staphylococcus Aureus among the Participants

Prevalence of S. aureus among children in schools

The prevalence of *S. aureus* within each school, and within the entire study population (520) was shown on table 2. Of the 520 study participants, the overall prevalence of *S. aureus* among children was 42.7% (222/520). The rest, 57.3% (298/520) were non carriers of nasal *S. aureus*. Based on the confidence interval (CI) of 95% and alpha value of 0.05, the difference in the carriage rate of *S. aureus* among children in different schools was not statistically significant (p-value 0.988) (Table 2).

Table 2: Distribution of *S. aureus* nasal carriage among children in schools.

	Number of Samples Examined	***Staphylococcus Aureus***	
		(P-Value = 0.988)	
Schools	**No (% *, %**, %***)**	**Positive**	**Negative**
		N (% *, %**, %***)	N (%*, %**, %***)
A	50 (100, 9.6, 9.6)	22 (44.0, 9.9, 4.2)	28 (56, 9.4, 5.4)
B	60 (100, 11.5, 11.5)	24 (40.0, 10.8, 4.6)	36 (60.0, 12.1, 6.9)
C	42 (100, 8.1, 8.1)	20 (47.6, 9.0, 3.8)	22 (52.4, 7.4, 4.2)
D	65 (100, 12.5, 12.5)	25 (38.5,11.3,4.8)	40 (61.5, 13.4, 7.7)
E	56 (100, 10.8, 10.8)	27 (48.2, 12.2, 5.2)	29 (51.8, 9.7, 5.6)
F	41 (100, 7.9, 7.9)	16 (39.0, 7.2, 3.1)	25 (61.0, 8.4, 4.8)
G	42 (100, 8.1, 8.1)	19 (45.2, 8.6, 3.7)	23 (54.8, 7.7, 4.4)
H	50 (100, 9.6, 9.6)	21 (42.0, 9.5, 4.0)	29 (58.0, 9.7, 5.6)
I	54 (100, 10.4, 10.4)	23 (42.6, 10.4, 4.4)	31 (57.4, 10.4, 6.0)
J	60 (100, 11.5, 11.5)	25 (41.7, 11.3, 4.8)	35 (58.3, 11.7, 6.7)
Total	520 (100, 100, 100)	222 (42.7, 100, 42.7)	298 (57.3, 100, 57.3)

% * within Schools, %** within *Staphylococcus aureus*, %*** of Total

Prevalence of S. aureus among children in urban schools

In this urban schools under study, 281 children were examined, out of which 120/281 (42.7%) were confirmed to be S. aureus nasal carriers. Sixty-six (55%) of the 120 S. aureus isolated were from males whereas 54/120 (45%) were from females (Table 3). Among the urban schools, high rate of S. aureus isolates was observed in school E, 48.2% (22/56), followed by school A, 44% (22/50), school H, 42% (21/50), school J, 41.7% (25/60), and school D, 38.5% (25/65).

Table 3: Age and sex distribution of *S. aureus* among the participants in the urban schools.

				Age (Years)			**Sex**	
School	**Educational Level**	**NE**	**NP**	**5 – 11**	**12 – 17**	**> 17**	**Male**	**Female**
				N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**
A	**Secondary**	50	22	1 (4.5)	21(95.5)	0 (0.0)	12(54.5)	10(45.5)
D	**Primary**	65	25	23 (92.0)	2 (8.0)	0 (0.0)	15(60.0)	10(40.0)
E	**Secondary**	56	27	2 (7.4)	23 (85.2)	2 (7.4)	16(59.3)	11(40.7)
H	**Primary**	50	21	18 (85.7)	3 (14.3)	0 (0.0)	10(47.6)	11(52.4)
J	**Secondary**	60	25	1 (4.0)	22 (88.0)	2 (8.0)	13(52.0)	12(48.0)
	Total	28	120	45 (37.5)	71 (59.2)	4 (3.3)	66(55.0)	54(45.0)

NE: Number Examined; NP: Number Positive for S. aureus

Prevalence of S. aureus among children in rural schools

In rural schools under study, 239/520 (46%) participants were involved in the study; out of which 102/239 (42.7%) were confirmed as *S. aureus*; of which, 57/102 (55.9%) were from male participants, while 45/102 (44.1%) were from females). The carriage rate of nasal *S. aureus* and the non-carrier rate in each school in the rural schools were also shown on table 4. Among the rural schools, high rate of nasal carriage of *S. aureus* was observed in school C, 47.6% (20/52), followed by school G, 45.2% (19/42), school I, 42.6% (23/54), school B, 40% (24/60), and school F, 39% (16/41).

Comparatively, there was higher prevalence of *S. aureus* nasal carriage in urban schools, 23.1% (120/520) as compared to 19.6% (102/520) in the rural schools. There was slightly higher prevalence of *S. aureus* nasal carriage among male participants in urban schools, 12.7% (66/520), as compared to that of males, 11.0% (57/520), in rural schools. Similarly, the frequency of *S. aureus* nasal carriage in urban females was 10.3% (54/520) as compared to 8.7% (45/520) in the rural females.

Table 4: Age and sex distribution of *S. aureus* among the participants in the rural schools.

				Age (Years)			Sex	
School	**Educational Level**	NE	NP	5 – 11	12 – 17	> 17	Male	Female
				N (%)	N (%)	N (%)	N (%)	N (%)
B	**Primary**	60	24	23(95.8)	1(4.2)	0 (0.0)	15 (62.5)	9 (37.5)
C	**Secondary**	42	20	1 (5.0)	18 (90)	1 (5.0)	10 (50.0)	10 (50.0)
F	**Primary**	41	16	16 (100)	0 (0.0)	0 (0.0)	8 (50.0)	8 (50.0)
G	**Secondary**	42	19	1 (5.3)	17(89.5)	1 (5.3)	10 (52.6)	9 (47.4)
I	**Primary**	54	23	21(90.3)	2 (8.7)	0 (0.0)	14 (60.9)	9 (39.1)
	Total	239	102	62(60.8)	38(37.3)	2 (2.0)	57 (55.9)	45 (44.1)

NE: Number Examined; NP: Number Positive for S. aureus

Of the 520 participants, there was high prevalence of *S. aureus* among children whose ages were above 17 years, 60% (6/10), followed by those within the age group of 12 years - 17 years, 45.8% (109/238). Participants within the age group of 5 years - 11 years had the least S. aureus carriage rate, 39.3% (107/272) (Table 5).

Two hundred and fifty-two (48.5%) out of 520 participants were males of which 123/252 (48.8%) were identified as *S. aureus*; 239/520 (51.5%) were females of which 99/239 (36.9%) were confirmed as *S. aureus*. The overall prevalence of *S. aureus* in males and females were 23.7% (123/520) and 19.0% (239/520) respectively indicating that S. aureus nasal carriage was more common in males (23.7%) than in females (19%) (Table 5).

Out of the 520 subjects that participated in the study, 281/520 (54%) resided in the urban area, of which 120/281 (42.7%) tested positive for *S. aureus*, with an overall prevalence of 23.1% (120/520); 239/520 (46%) of the participants lived in the rural area, out of which 102/239 (42.7%) were confirmed to be nasal carriers of *S. aureus* with overall prevalence of 19.6% (102/520). This finding indicates that *S. aureus* nasal carriage rate was almost the same in both urban and rural schools (Table 5).

Table 5: Prevalence and risk factors of *Staphylococcus aureus* among study participants (socio-demographic variables).

Characteristics	**Sub-variables**	**Total Examined (%)**	***Staphylococcus aureus***		
(Variables)			**Positive**	**Negative**	**P-Value**
			N (%*, %**)	N (%*, %**)	
Age	5 - 11	272 (52.3)	107 (39.3, 20.6)	165 (60.7, 31.7)	
	12 - 17	238(45.8)	109 (45.8, 21.0)	129(54.2, 24.8)	
	> 17	10 (1.9)	6 (60.0, 1.2)	4 (40.0, 0.8)	0.181
	Total	520 (100)	222 (42.7)	298 (57.3)	
Sex	Male	252 (48.5)	123 (48.8, 23.7)	129 (51.2, 24.8)	
	Female	268 (51.5)	99 (36.9, 19.0)	169 (63.1, 32.5)	0.006
	Total	520 (100)	222 (42.7)	298 (57.3)	
Residence	Urban	281 (54.0)	120 (42.7, 23.1)	161 (57.3, 31.0)	
	Rural	239 (46.0)	102 (42.7, 19.6)	137 (57.3, 26.3)	0.995
	Total	520 (100)	222 (42.7)	298 (57.3)	
Educational Status	Primary	270 (51.9)	109 (40.4, 21.0)	161 (59.6, 31.0)	
	Secondary	250 (48.1)	113 (45.2, 21.7)	137 (54.8, 26.3)	0.266
	Total	520 (100)	222 (42.7)	298 (57.3)	
Family Size: No in the Family	≤ 4 members	162 (31.2)	79 (48.8, 15.2)	83 (51.2, 16.0)	
	5 –7 member	345 (66.3)	133 (38.6, 25.6)	212 (61.4, 40.8)	
	> 7 members	13 (2.5)	10 (76.9, 1.9)	3 (23.1, 0.6)	0.004
	Total	520 (100)	222 (42.7)	298 (57.3)	
Number of Children in Classroom of Participants	10 - 30	422 (81.2)	173 (41.0, 33.3)	249 (59.0, 47.9)	
	31 - 50	71 (13.7)	30 (42.3, 5.8)	41 (57.7, 7.9)	
	> 50	27 (5.2)	19 (70.4, 3.7)	8 (29.6, 1.5)	0.011
	Total	520 (100)	222 (42.7)	298 (57.3)	

%* Percentage within Sub-variable, %** Percentage of Total (520)

Risk factors of S. aureus

Among the 520 school children that participated in this study, sex of children (p-value = 0.006), family size of each child (p-value = 0.00), and number of children per classroom (p-value = 0.011) were statistically significant

risk factor for nasal colonization of *S. aureus*. Nevertheless, other socio-demographic characteristics examined were not risk factors for *S. aureus* (Table 5 and Table 6).

Table 6: Other risk factors of *staphylococcus aureus* among study participants (clinical variables).

Characteristics (Variables)	Sub-Variables	Total Examined (%)	Positive	Negative	P-Value
			N (%*, %**)	N (%*, %**)	
Use of Antibiotics in the Last One Month	Yes	71 (13.7)	29 (40.8, 5.6)	42 (59.2, 8.1)	
	No	449 (86.3)	193 (43.0, 37.1)	256 (57.0, 49.2)	
	Total	520 (100)	222 (42.7)	298 (57.3)	0.735
History of Hospitalization	Yes	89 (17.1)	37 (41.6, 7.1)	52 (58.4, 10.0)	
	No	431 (82.9)	185 (42.9, 35.6)	246 (57.1, 47.3)	0.815
	Total	520 (100)	222 (42.7)	298 (57.3)	
History of Visit to Hospital/Clinic	Yes	105 (20.2)	41 (39.0, 7.9)	64 (61.0, 12.3)	
	No	415 (79.8)	181 (43.6, 34.8)	234 (56.4, 45.0)	0.398
	Total	520 (100)	222 (42.7)	298 (57.3)	
History of Surgery	Yes	9 (1.7)	4 (44.4, 0.8)	5 (55.6, 1.0)	
	No	511 (98.3)	218 (42.7, 41.9)	293 (57.3, 56.3)	0.915
	Total		222 (42.7)	298 (57.3)	
living with a Health Care Worker	Yes	59 (11.3)	25 (42.4, 4.8)	34 (57.6, 6.5)	
	No	461 (88.7)	197 (42.7, 37.9)	264 (57.3, 50.8)	0.958
	Total	520 (100)	222 (42.7	298 (57.3)	
History of having Chronic Disease	Yes	14 (2.7)	6 (42-9, 1.2)	8 (57.1, 1.5)	
	No	506 (97.3)	216 (42.7, 41.5)	290 (57.3, 55.8)	0.99
	Total	520 (100)	222 (42.7)	298 (57.3)	

%* Percentage within Sub-variable, %** Percentage of Total (520)

DISCUSSION

In this cross-sectional survey, we enrolled 520 healthy school children from primary and secondary schools in Nsukka urban and its environs. The children's ages ranged from 5 years - 18 years with a mean age of 11.4 years (SD 3.5). Analysis of the socio-demographic data revealed that 54% (281/520) of participants were in the urban schools, of which 49.1% (138/281) of them were males and 50.9% (143/281) were females. The rural schools contributed 46% (239/520) of the total study subjects, out of which 47.7% (114/239) were males whereas 52.3% (125/239) were females.

In this comparative cross-sectional survey among 520 subjects in our study area, we found that the carriage rate of nasal *S. aureus* was 42.7%. The result of our study showed that out of the 520 participants, 222 tested positive for *S. aureus* nasal carriage. Our finding was consistent with some similar studies conducted on healthy school children in Kathmandu, Nepal (40%), Bahir Dar, Ethiopia, (41%); Jimma, Ethiopia (47%) [13, 14, 15]. Some researchers in Nigeria on the nasal carriage rate of *S. aureus* on healthy school children reported higher prevalence of *S. aureus* than our finding: Nsofor et. al. [16] in Elele, River State reported a carriage rate of 62.9%; Nsofor et. al. [12] in Owerri, Imo state reported a prevalence rate of 56.3%; Shiv et.al. [17] reported a *S. aureus* nasal carriage rate as 52.5%. On the contrast, some related studies in Nigeria and other parts of the world reported lower prevalence of S. aureus nasal carriage on healthy school children when compared to our finding. Their reports include: Okada, Edo State (18.3%); Anambra State (30.1%) [18,19]. Others include: Ashanti, Ghana (22.1%); Gonder, Ethiopia (23%); Indian (35%); Kashan Iran (26.3%) [20- 23].

The variation in the colonization rate of *S. aureus* in the nares of humans in different geographical locations in either children or adult populations could be due to the following factors: geographical distribution of the study participants where climatic conditions might play vital role in *S. aureus* nasal carriage; population characteristics such as population size or density, spatial distribution of individuals, age structure etc. other factors might be due

to the sampling techniques, isolation and identification methods used by different researchers in isolating and identifying *S. aureus*. Of the 120 children who tested positive for *S. aureus* in the urban schools, 55% (66/120) were males whereas 45% (54/120) were females. Similarly, of the 102 participants who had nasal carriage of *S. aureus* in the rural area, 55.9% (57/102) were males whereas 44.1% (45/102) were females. However, in both urban and rural schools combined, males also have more nasal carriage rate of *S. aureus* than females: 48.8% (123/252) and 36.9% (99/268) respectively. The result was in line with previous studies conducted in Nigeria and other parts of the world on healthy children: Nsorfor et al. [12] in Owerri, Nigeria reported 51.3% nasal carriage rate in males and 48.7% in females. Other reports include: In Anambra, Nigeria [19], 54.5% in males and 45.5% in females; Gonder, Ethiopia [21], 55.2% in males and 44.8% in females; Iran [24], 56% in males and 44% in females. This indicates that in both rural and urban schools, male children had higher prevalence of nasal *S. aureus* than female children. The reason might be because males are more often involved in sports (combative sports) and other social activities than females which make them (males) to be more in contact with each other and more spread of *S. aureus* among themselves.

We noticed that the nasal carriage rate of *S. aureus* in children increased as the age of the children increases. Children within the ages of 5 years - 11 years had a carriage rate of 39.3% (107/272); followed by those whose ages were between 12 years - 17 years, 45.8% (109/238). Children whose ages were above 17 years had a carriage rate of 60% (6/10). This observed increase in the nasal carriage rate of *S. aureus* as the children grow in age might be due to changes in the body biochemistry, secondary sex characteristics and social life of the children as they grow from childhood to adulthood. Older children do socialize more often than the younger ones through sports and other outdoor activities that might lead to spread of *S. aureus* among them. The difference in the S. aureus nasal carriage rate among children of different age groups was not statistically significant (p-value = 0.181), hence, *S. aureus* nasal carriage was not dependent or associated with age. Age of a child was not a risk factor for *S. aureus* nasal carriage.

The nasal carriage rate of *S. aureus* in the rural schools and urban schools under study were separately evaluated and compared. The nasal carriage rate of rural participants was 42.7% (102/239) and was similar to the urban participants, 42.7% (120/281). This showed that living in the urban area or rural area was not a determinant or risk factor of *S. aureus* nasal carriage (p-value = 0.995).

High prevalence of nasal *S. aureus* was observed among children who had family size of more than 7, (76.9%) as compared to those that had family size of ≥4 (48.8%) and those that had a family size of 5 members - 7 members (38.6%). The reason for the high rate of nasal carriage of *S. aureus* among children with family members above 7 might be frequent contacts among members of the family as a result of overcrowding which encourage the spread of *S. aureus*. Therefore, number of individuals in the family of a child was a significant risk factor for *S. aureus* nasal colonization (p-value = 0.004).

In a similar vein, the number of children in a classroom was statistically a significant risk factor for nasal carriage of *S. aureus* (p-value = 0.011). We found that children in classroom of more than 50 pupils or students had a very high nasal carriage of *S. aureus* (70.4%) when compared to those that were in class containing 31 children - 50

children (42.3%) or 10 pupils - 30 pupils or students (41%). The reason for this might be as a result of overcrowding that gave rise to frequent body contacts with resultant spread of *S. aureus* among the children.

Our result showed that among all the socio-demographic variables examined, only sex; family size; and number of children per classroom of a child, were identified as significant risk factors for *S. aureus* nasal colonization (p-values were <0.05).

S. aureus nasal colonization was not dependent or associated with other socio-demographic characteristics tested, and therefore, these variables were not risk factors for *S. aureus* nasal carriage.

CONCLUSION

The prevalence of *S. aureus* among children was 42.7%. Sex, family size, and number of children per classroom were significantly associated with nasal carriage of *S. aureus* in this part of the world and therefore, independent risk factor for it. Data generated in this study will help policy makers in identifying priority areas or potential burden of *S. aureus* in the community and among children in particular so as to take appropriate interventions measures that will help in reducing *S. aureus* colonization, spread and infections. This can be done through periodic surveillance and screening of target population, decolonization of carriers and introduction of measures that will enhance regular washing if hands and sanitation.

SIGNIFICANCE OF THE RESEARCH

In this paper we showed that there is high prevalence of *Staphylococcus aureus* in this part of Nigeria and that sex, population of children in a classroom and numbers of family members are associated with the *Staphylococcus aureus* nasal carriage. *Staphylococcus aureus* nasal colonization has been identified as a reservoir and a source of human infections. There is an important association between nasal carriage of *S. aureus* and the development of subsequent infections by *S. aureus*. Our work will motivate government to make policies that will help eliminate or reduce nasal colonization of *S. aureus* and its subsequent infections. Our finding will also help researchers who want to further study the molecular characterization of the nasal *Staphylococcus aureus*.

DATA AVAILABILITY

The dataset generated and analyzed in this study are available from the corresponding author upon request.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTION

Ogbuanya C, conceived and designed the study, participated in data and sample collection, laboratory work, data analysis and drafting of manuscript. Attama AA and Nnamani PO supervised and reviewed the study. All authors read and approved the final manuscript.

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