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Risk of *Staphylococcus aureus* nasal carriage among food handlers: implications for foodborne illnesses

Ebidor Lawani-Luwaji*, Alade Tolulope, Iriakuma Baratuaipre

Department of Medical Laboratory Science, Niger Delta University, Wilberforce Island, Nigeria.

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ABSTRACT

The presence of microorganisms or their toxin in food materials is a predominant problem in the food industry, posing significant hazards to public health. *Staphylococcus aureus*, a bacterium commonly colonising human skin, nose, and gut, is a leading cause of foodborne infections. Asymptomatic carriers can contaminate food by touching it or through respiratory secretions, leading to staphylococcal food poisoning. This study aims to assess the prevalence and antibiotic resistance patterns of *Staphylococcus aureus* among food handlers. Nasal swabs from food handlers were analysed using standard microbiological techniques. The study found that 57% of restaurant workers and food handlers had *Staphylococcus aureus* in their nasal cavities. Among the participants, women had a higher prevalence at 94%, while men had a prevalence rate of 6%. The chi-square analysis revealed no significant differences in the occurrence of *Staphylococcus aureus* across different genders or age groups, indicating that neither gender nor age significantly influenced the prevalence. The age group with the highest prevalence rate was 23-28 years at 23.5%. Levofloxacin and Rifampicin showed the highest sensitivity rates (87%), while all isolates resisted Norfloxacin. These findings highlight the critical need for enhanced food hygiene education and the use of protective equipment among food handlers to prevent foodborne illnesses. Addressing antibiotic resistance is also fundamental for public health interventions.

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1. Introduction

Food is a fundamental necessity for human survival; however, it can become a significant source of suffering, diseases, and even death when contaminated. Annually, contaminated food results in approximately 600 million foodborne illnesses and 420,000 fatalities have been reported worldwide. This is a primary concern worldwide, with bacteria responsible for two-thirds of all outbreaks. *Staphylococcus aureus* is the most frequently encountered bacteria responsible for gastroenteritis (1).

*Corresponding author. Tel.: +23480642252
E-mail address: ebilawani-luwaji@ndu.edu.ng

The contamination of foodstuffs by microorganisms or their by-products, including toxins, is a major concern in the food industry, posing substantial risks to public health. A key contributor to infections is *Staphylococcus aureus*, a widespread pathogen that is becoming increasingly resistant to antibiotics (2). Ingesting contaminated food can lead to staphylococcal food poisoning, which occurs when staphylococcal enterotoxins are absorbed into the body (1).

Danbolt identified the association between nasal carriage and staphylococcal infections in 1931 (3). Since then, several studies have confirmed this correlation by identifying the identical genotypes in nasal and infecting *S. aureus* strains (4).

Nasal carriers can spread the bacteria through their hands and respiratory secretions, leading to staphylococcal food poisoning. Poor personal hygiene is a key cause of contamination (5).

Staphylococcal gastroenteritis is one of the most common foodborne diseases that result from consuming one or more staphylococcal enterotoxins (SEs) in foodstuffs contaminated with the bacterium. Poor personal hygiene also affects food vendors' functioning in food service establishments. Due to the colonisation or skin infections of food vendors, contamination of the hands, or dissipation through sneezing or coryza, there is continual contamination of foods by *Staphylococcus aureus* (6).

The capability of this bacterium to produce enterotoxins depends on the storage or preservation method, which might affect its metabolic activity in the food. Other Staphylococcus species can retain enterotoxigenic genes and are occasionally implicated in staphylococcal food poisoning epidemics. Carriers of antibiotic-resistant *Staphylococcus aureus*, which are enterotoxigenic, will enable its continued resistance. It has been increasingly linked with invasive infections, especially severe community-acquired pneumonia (CAP) in children, with an increasing prevalence worldwide (6).

The nasal carriage of *S. aureus* is a significant reservoir for transmission, with carriers contaminating food through their hands and respiratory secretions (3). This is particularly concerning in food-service set-up with poor personal hygiene practices (5). In developing countries, such as Nigeria, foodborne illnesses linked to *S. aureus* are under-reported despite the potential for significant public health effects. Also, the increasing prevalence of antibiotic-resistant *S. aureus* confounds treatment and control measures, intensifying the need for localised surveillance of resistance patterns (6).

This study aims to determine *Staphylococcus aureus*'s prevalence and antibiotic susceptibility patterns among food handlers in a southern Nigerian community. The goal is to inform public health interventions and improve food safety practices.

2. Materials and Methods

2.1. Study design/ study area

The research design for this study was a cross-sectional study involving the collection of nasal swab samples from apparently healthy food vendors in the Nembe community, Bayelsa State, Nigeria.

2.2. Sampling method

To minimise selection bias, participants for the study were randomly selected from the population of food handlers in the Nembe Community, Bayelsa State. This riverine community was chosen due to its unique socio-economic characteristics and reliance on local food vendors, which makes it an ideal setting for assessing the incidence of *Staphylococcus aureus* nasal carriage

among food handlers. A significant limitation of this study is the presence of a group of food handlers who were reluctant to participate because they feared the results could negatively impact their business operations.

2.3. Sample population size

The sample size was computed using the formula by Taro Yamane (7)

$n=100/(1+N(e)^2)$, n- sample size, N- sample, e- margin of error. , n=?, N=100, e=0.1

n=100/(1+100(0.01)2)

n=100/(1+100(0.02)

n=100/(1+2)

n=100/3, n=33.3, n=33

2.4. Ethical consideration

We received formal permission from the community leader and environmental health officers. After explaining the study's concept to all food handlers and restaurant workers, we also obtained informed consent.

2.5. Sample collection

Nasal swab samples were collected using swab sticks from apparently healthy food vendors in Nembe, Bayelsa State, Nigeria. The collected specimens were then taken to the diagnostic laboratory for bacteriological analysis.

2.6. Sample analysis

The nasal swab samples were inoculated on blood and MacConkey agar, and the plates were incubated at 37°C for 24 h. The bacterial isolates were identified using standard bacteriological procedures, including Gram staining and biochemical tests as described by Cheesbrough (8).

2.7. Antibiotics sensitivity test

We used a commercially prepared multidisc with a known minimum inhibitory concentration. An overnight broth culture was used for the assay using a 1:100 dilution of the bacteria to flood the surface of the nutrient agar. The broth culture was tipped out from the plates and left for 30 min on the bench in an inverted position. Then, antibiotic-sensitive discs were aseptically positioned on the surface of the agar and incubated for 24 h. The inhibition zone for each antibiotic was measured using the standards of the Clinical and Laboratory Standards Institute (CLSI) (9).

Susceptible: ≥21 mm (zone diameter)

Intermediate: 16-20 mm

Resistant: ≤15 mm

2.8. Statistical analysis

All statistical analyses were performed using Scientific Package for Social Sciences (SPSS) version 20.0.

3. Results

The demographic features of the study population are presented in Table 1, which gives an overview of the number of participants by age and gender. The results show that most participants were female (Table 2), accounting for 90.6% of the total population, indicating a higher prevalence of 0.5 compared to 0.03 males. The highest growth rate of *S. aureus* was found in participants aged 23 to 28 at 23.5% (Table 2).

Table 1. Demographic analysis

Parameters		Frequency	Percent
gender distribution			
	Male	3	9.4
	Female	29	90.6
	Total	32	100
age distribution			
	17-22	4	12.5
	23-28	5	15.6
	29-34	9	28.1
	35-40	7	21.9
	41-46	4	12.5
	47-52	2	6.3
	53-58	0	0
	59-64	1	3.1
	Total	32	100

Table 2. Growth of *Staphylococcus aureus*

		Growth of ***Staphylococcus*** **spp**		
		Frequency	**Percent**	**Prevalence**
gender distribution				
	Male	1	5.9	0.03
	Female	16	94.1	0.5
	Total	17	100	
age distribution				
	17-22	3	17.6	0.09
	23-28	4	23.5	0.13
	29-34	3	17.6	0.09
	35-40	3	17.6	0.09
	41-46	2	11.8	0.06
	47-52	1	5.9	0.03
	53-58	0	0	0
	59-64	1	5.9	0.03

Table 3. Antibiotics susceptibility pattern of the bacterial isolate

Antibiotics	Resistance (%)	Susceptible (%)
Ciprofloxacin 10mcg	7(43.7%)	9(56%)
Norfloxacin 10mcg	16(100%)	0
Amoxil 20mcg	14(87.5%)	2(12.5%)
Streptomycin 30mcg	4(25%)	12(75%)
Rifampicin 20mcg	2(12.5%)	14(87%)
Erythromycin 30mcg	6(37.5%)	10(62%)
Chloramphenicol 30mcg	12(75%)	4(25%)
Ampicillin 20mcg	14(87.5%)	2(12.5%)
Gentamycin 10mcg	11(68.7%)	5(31%)
Levofloxacin 10mcg	2(12.5%)	14(87%)

Table 2 shows the gender and age-based prevalence of *Staphylococcus aureus* amo The study found that 57% of food handlers and restaurant workers had *S. aureus* in their nasal cavities. Among the participants, women had a higher prevalence at 94%, while men had a prevalence rate of 6%. However, statistical analysis showed that there was no significant difference in the frequency of *S. aureus* between genders ($\chi^2 = 0.0$, $p = 1.0$) or age groups ($\chi^2 = 0.0$, $p = 1.0$), indicating that neither gender nor age significantly influenced the prevalence. The age group with the highest prevalence rate was 23-28 years at 23.5%, followed by 17-22 years, 29-43 years (17.6%), and 35-40 years (17.6%).

The results (Table 3) of the test on antibiotic sensitivity to *S. aureus* revealed that levofloxacin and rifampicin were the most effective antibiotics with 87% sensitivity (n=14) followed by streptomycin with 75% (n=12), erythromycin with 62% (n=10), and ciprofloxacin with 56% (n=9). In contrast, norfloxacin showed the highest resistance with 100% (n=16), followed by amoxicillin and ampicillin with 87.5% (n=14) resistance.

The inhibition zone for each antibiotic was measured using the Clinical and Laboratory Standards Institute standards (CLSI).

Susceptible: ≥21 mm (zone diameter)

Intermediate: 16-20 mm

Resistant: ≤15 mm

4.Discussion

Food handlers carrying *Staphylococcus aureus* in their nasal passages pose a significant risk of causing foodborne illnesses. This study conducted in the Nembe community found that the prevalence of Staphylococcus aureus nasal carriage among food vendors was 57%. This percentage is consistent with previous studies conducted in other parts of Nigeria, such as Lagos, where Egwuatu et al. (10) and Eke et al.

(11) reported even higher rates of 57.5% and 60%, respectively.

Therefore, adequate measures must be implemented to prevent contamination and transmission of *S. aureus* in food handling and preparation settings to ensure public health and safety.

However, this contrasts with the low prevalence of *S. aureus* in similar studies in other areas, like a university community in Ile ife with a prevalence of 37.14% (12), in Maiduguri where they recorded a prevalence of 16.8% (13). Okoro et al. (14) recorded a prevalence of 28.1% in Eleme and Abuja (15.5%) (15). These variations in the nasal carriage rate of *S. aureus* could be due to the study population's environmental differences.

This research shows that the prevalence of nasal carriage of *S. aureus* was higher in females (53%) than males. This finding is consistent with the report of Akinnola et al. (16), which showed 63% female involvement, but contradicts the report of Ibrahim & Sule (13), which suggested a higher prevalence in men. This difference can be attributed to the tradition and culture of the study area, where men are more involved in handling the sale of food than women. Isibor and Otabor (17) found no significant difference between gender and rate of nasal carriage of the pathogen.

Report from this study shows that the range of 23-28 has the highest prevalence (25%) as against (19%) in respondents between the age range 34-40 and 31-35(17%), which is consistent with the findings of Eke et al. (12). Many young adults enter the food industry to earn money while waiting for better job opportunities. The job can be physically demanding, so older individuals often prefer to supervise while younger adults attend to customers.

The results of the chi-squared tests for both gender and age distributions indicate that there is no significant difference in the frequency of *Staphylococcus* spp between males and females in this sample, with a p-value of 1.0

Moreover, the antibiotic susceptibility profile of the isolates to the used antibiotics showed susceptibility to rifampicin, levofloxacin, streptomycin, and erythromycin, except for amoxil, gentamycin, and ampiclox, which have less than 40% susceptibility, and norfloxacin, which is 100% resistant.

The prevalence of multi-drug-resistant pathogens in Nigeria is increasing due to various factors, including drug misuse, self-medication, lack of trained medical personnel, and poverty. A meta-analysis study has revealed that *S. aureus* in Nigeria has developed resistance to commonly used antibiotics such as beta-lactam class antibiotics, sulphonamides, tetracyclines, chloramphenicol, and vancomycin (18).

These findings reinforce the need for protective measures, such as increasing public awareness programs, regularly monitoring food vendors for foodborne pathogens, and providing extensive training on primary health care and hygiene. Encouraging food vendors to wear nose masks and conducting regular medical examinations of correspondents could help prevent the spread of resistant strains of *S. aureus*.

The findings also shows the significance of implementing efficient quality control systems in direct contact with food products, such as good manufacturing practices and standard operational procedures. Future research addressing effective methods for sustained eradication of staphylococcal nasal carriage is warranted to reduce the high risk of subsequent infection.

5. Conclusion

Proper hygiene practices in food preparation are paramount for ensuring food safety. One of the most fundamental steps in this process is thoroughly washing hands with soap and water before and during food preparation. When an individual suffers from gastroenteritis, it is recommended that they avoid preparing meals and delegate this responsibility to someone else. Protective gloves, face masks, and aprons are strongly encouraged while handling food, and individuals are advised to avoid coughing, sneezing, or talking around the food.

Also, avoiding unhygienic habits such as picking your nose or using your hands to clean your nostrils while preparing food is vital. The food preparation area should be kept clean, and it is recommended to use a different chopping board for each type of food or wash it thoroughly before using it for different ingredients. By following these practices, individuals can significantly reduce the risk of food contamination and ensure the safety of the food they prepare. The study was limited to one community, which may not represent other regions. The methods used to identify *S. aureus* were conventional. A longitudinal study could provide more comprehensive results in the future. A significant limitation is the hesitancy of certain food handlers to participate due to concerns that the results could negatively impact their business.

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Authors' contributions

EL conceptualised the research, while IB and TA conducted the experimental work. EL was responsible for the manuscript preparation. TL also contributed to writing and proofreading the manuscript. All authors reviewed and approved the final manuscript.

Declaration of competing interest

The authors have no competing interest

Data availability

All data related to the study have been provided in the manuscript

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