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Antibiogram Types Of *Staphylococcus Aureus* Isolated From Nostrils Of Primary School Pupils In Abuja Metropolis, Nigeria

Philips Ogbeide ORHUE[1], Comfort Ojochenemi JOHN[1], Uwaifoh AKPAMU[2*]

[1]Department of Medical Microbiology, Faculty of Medical Laboratory Sciences, Ambrose Alli University, Ekpoma, Nigeria.
[2]Department of Physiology, Faculty of Basic Medical Sciences, Federal University Oye-Ekiti, Oye-Ekiti, Nigeria.
*Corresponding author: uwaifoh.akpamu@fuoye.edu.ng; Phone number: +2348032770151.

Abstract: *Staphylococcus aureus* (*S. aureus*) infestation is gaining public health importance owing to high morbidity and mortality risks and involvement of several factors in its colonization and antimicrobial susceptibility. With the rising population situation in Nigeria's capital city, the prevalence is hypothesized to be changing. This study therefore determines the nasal carriage rate of *S. aureus*, antimicrobial sensitivity and antibiogram pattern among primary school pupils in Abuja metropolis. This school-based cross-sectional study obtained nasal swab from consented pupils using sterile cotton swabs moistened with sterile normal saline. Identification of *S. aureus* was carried out using standard techniques and via standard methods of culturing on Mannitol salt Agar media. Antibiogram was determined by the disc diffusion method using 21 antibiotics. The data were analyzed using simple descriptive statistics. Overall, 45.7% of the sampled 151 pupils yielded significant *S. aureus* growth, highest among 11-12 (51.7%) age group. The isolates were mostly sensitivity to Augmentine (87.0%), Cefotaxime (85.5%), Ofloxacin (79.7%) and Gentamycin (76.8%) but less sensitive to Ampicillin (10.1%), Amoxicillin (11.6%) and Tetracycline (13.0%). The aminoglycosides (29%), beta-lactams (24.2%) and Cephalosporins (20.6%) have the highest sensitivities while penicillin group (2.1%) had the least. Ajumali's mnemonic coding showed 30.4% multidrug-resistant with the most sensitive strain as 0776777 and most resistant strains were 0200000 and 0200020 and 0200006. This finding showed high prevalence and multi-drug resistant *S. aureus* among the pupils with significant strain diversity. These findings call for the need of periodic studies of this nature in different communities to shed light on the relevance of the current antibiotics in use.
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Key words: Antibiotic sensitivity; *Staphylococcus aureus;* Antibiogram; Ajumali's mnemonic coding; Primary school children

1. Introduction

Staphylococcus aureus (*S. aureus*) is a Gram-positive, non-motile, non-spore forming, anaerobic bacteria, which appear in spherical shape and has become a human pathogen of increasing concern to public health (Ajoke et al., 2012). It is a common skin and nasopharynx commensal and a pathogen intermittently causing severe infections with high morbidity, mortality and loss of productivity due to increased direct medical cost (Schmidt et al., 2015; Linz et al., 2023). It is the causative agent of several mild to fatal infections, giving rise to sepsis, deep abscesses, boils, conjunctivitis, and pneumonia (Ugwu et al., 2016) and made it one of the principal causes of hospital-acquired infections in patients undergoing surgery, dialysis and intensive care (Abubakar, 2020).

S. aureus nasal carriership could also lead to significant levels of infection through community transmission (Rasamiravaka *et al.,* 2013) as approximately 20–30% of human globally is persistently colonized with *S. aureus* in the anterior nares, with 60% projected to be transiently colonized at some point (Habeeb et al., 2014). The main vector for transmission in healthcare and community environment is postulated to be nasal carriership and this has been well established (Ansari *et al*., 2016).

There is growing evidence that *S. aureus* nasal colonization is spreading among healthy pre-school children (Chen, *et al*., 2020). Previous Studies reveals that carriership rates vary with environment, seasonality, age and sex (Chen *et al*., 2014). In different parts of the world, studies reveal a prevalence rate of among children (Neupane et al., 2018) to range from 29.6% in Iran (Sedighi et al., 2011), 34% in Belgium (Jourdain *et al.*, 2011), 35% in India (Pathak *et al.*, 2010) and Republic of Korea (Bae *et al.*, 2012), 17.5% in Vietnamese children (Tran et al., 2023) and 20 to 30% among Dutch children less than 6 years and

40 to 50% between the ages of 6 to 12 years (Eibach *et al.,* 2017). In Nigeria, 56.3% rate was reported in apparently healthy children in Owerri (Nsofor et al., 2015) and36.3% among children attending the outpatient clinic of a tertiary hospital in Ibadan (Tuta et al., 2019).

According to the United Nations-World Population Prospect (2021), Abuja the capital city of Nigeria, had approximately 3,464,000 people, a densely populated suburban region with a high population of lower-social economic status with evidence of overcrowding and poor waste management. Research on diseases in Africa currently has focused on malaria, HIV and tuberculosis, while major bacteria pathogens like *S. aureus* are not readily researched, even when several studies recorded an increased high rate of infections. Abuja appears to be at increased risk for the emergence of *S. aureus* carriage in the light of several studies (Anowai et al., 2018; Godwin, 2022). Over the past 20 years, the incidences of both community-acquired (CA) and hospital-acquired (HA) *S. aureus* infections have increased (Goel and Garima, 2023); with the increased abuse use of antibiotics, effective therapeutics agent has been difficult to identify, leading to concomitant increase in the emergence of multi-resistant strains (Usman and Syed, 2018). This has led to an increased number of nosocomial (hospital) and community-acquired infections, increased health care costs, disabilities and deaths (Oke et al., 2013). In addition, there is a paucity of data regarding the antibiogram types of *S. aureus;* especially on isolates from the nostrils of pupils in a growing capital city like Abuja. Thus, this study determines the nasal carriage rate of *S. aureus*, antimicrobial sensitivity and antibiogram pattern among primary school pupils in Abuja metropolis.

2. Materials and methods

2.1. Study location

The study location (Abuja) lies within longitudes 7º 28' 29.738" and 7º 30' 27.094" East of the Greenwich Meridian and latitudes 9º 5' 3.91" and 9º 6' 42.555" North of the equator. Abuja city is located in the central part of Nigeria, North of confluence of the Niger and Benue Rivers. The geography of the area is defined by two renowned rocks- the Zuma Rock, from whose base the Federal Capital Territory (FCT) begins, and Aso Rock, which is located to the East of the city. Abuja's location strategically positioned at the intersection of two highways linking the Northern and Southern parts of the country, making it more accessible. The distance from Abuja to all parts of the country is less than 965 km (600 miles) on every side. This centrality and accessibility are actually one of the reasons the new capital city was created.

Abuja stands at an elevation of 840 m (2760 ft.) above sea level. This elevation and geographical location give Abuja a mild weather. The Abuja area has two distinct seasons: the rainy season, which lasts from April to October with rainfall ranging from 305 to 762 mm (12-30 in.) and temperatures rising up to 40 °C in May, and the dry season, which lasts from November through March with dry winds lowering the temperature to as low as 12 °C. Because of its abundant rainfall, rich soil and the location within the Guinea-Savanna vegetation zone, the region is agriculturally productive, with maize and tuber of yams as the dominant crops (Agbelade et al., 2017).

2.2. Study design/ population

The study employed the cross-sectional survey of pupils in Abuja metropolis, Nigeria. The subjects were pupils from the public primary schools in Karmo, Gwarinpa and Life-camp communities in Abuja metropolis, Nigeria.

2.3. Inclusion and exclusion criteria

All apparently healthy pupils of ages 5 and 12 who obtained consent from their legal guardians from three recruited schools of three different communities in Abuja, Nigeria, were included in this study. Pupils who were unable to obtain consent, sick and presenting symptoms of respiratory tract infections, and above 12 years of age were excluded. Pupils with evidence of recent antibiotic administration and exposure to health care facility 2 weeks prior to sample collection, were also excluded from the study.

2.4. Ethical considerations

Ethical clearance was obtained from the Ethical Review Committee of the Federal Capital Territory Health Research Ethics Committee.

2.5. Sample size determination

Sample size was determined using Fisher's formula (Charan and Biswas, 2013); $N = [Z^2(pq)]/[d^2]$. Where N = the desired sample size, Z = standard variation set at 1.96 (corresponds to 95% confidence Interval), p= 36.3 % (expected proportion in population based on previous study prevalence of 36.3% reported by Tuta et al., 2019), q=1-p and d = degree of accuracy desired set at 0.05. using this formula, the estimated sample size was 355 children.

2.6. Sampling techniques

The pupils were randomly selected using a multistage sampling technique. Three communities were selected based on the availability of basic social amenities, followed by choosing a central primary school that is densely populated within the community. And lastly, all pupils who obtained consent from their parents or legal representatives were included in the study. The study was conducted within three months between September and November.

2.7 Sample collection, isolation and identification

Swab samples were collected aseptically using swab sticks from the anterior nares of the participants. The collected samples were labeled with a numeric number and immediately transferred into the tube containing few drops of sterile normal saline and then transported within 2 hours to Medical Biotechnology Department Laboratory, National Biotechnology Development Agency Abuja for analysis.

The swab sticks were streaked directly on Mannitol salt agar (MSA) (Oxoid, Basingstoke, United Kingdom) and incubated at 370C for 24 hours. S. aureus was identified following standard procedures (Doaa and Salwa, 2012) based on colonial characteristics from the cultured plate, with a distinct yellowish colouration on Mannitol salt agar (indicating Mannitol fermentation on the plate). Further identification of S. aureus colonies were performed by the addition of two drops of 3% Hydrogen Peroxide on a sterile glass slide, then a single colony from each of the culture of the samples was mixed in a drop with a sterile nichrome wire loop. Formation of bubble in the hydrogen peroxide drop indicates the positive result for catalase test. Results for catalase test were noted down for each of the isolate. The use of fresh human plasma on a slide was further used to confirm the suspected isolates to be S. aureus, only those Staphylococci showing rapid clumping were regarded as coagulase-positive.

2.8. Antimicrobial susceptibility test

Whatman No.1 filter paper discs with a diameter of 6 mm were punched out with a paper puncher and separated into 21 bijoux bottles of 100 disc each and sterilized in a hot air oven at 140 0C for 2 hrs. The bottles and contents were allowed to cool to room temperature. Antibiotic stock solutions (table 1) were prepared with known concentrations of the antibiotic powder in sterile distilled water and was diluted to a required concentration of working solution in line with Clinical Laboratory Standards Institute (CLSI) recommendations (CLSI, 2019). The discs were aseptically impregnated with 1 ml of the pre-prepared antibiotic stock solution and allowed to absorb for 10 minutes and the bottles' caps were partly screwed down and allowed to dry overnight in a 37 0C incubator (Orhue, 2016).

Table 1. Preparation of stock antibiotic solutions for filter paper disc impregnation

S/N	Antibiotics	Tablet conc.	Volume of distilled water to dissolve tablet	Conc. Of solution	Dilution needed	Stock to impregnate 100 disc	Disc conc
1	Ampicillin	250mg	8.33ml	30mg/ml	10^{-1}	3000ug/ml	30ug
2	Amoxicillin	500mg	16.7ml	30mg/ml	10^{-1}	3000ug/ml	30ug
3	Ampiclox	500mg	50ml	10mg/ml	10^{-1}	1000ug/ml	10ug
4	Unasyn	375mg	37.5ml	10mg/ml	10^{-1}	1000ug/ml	10ug
5	Augmentine	375mg	37.5ml	10mg/ml	10^{-1}	1000ug/ml	10ug
6	Floxapen-Flucloxacillin	500mg	50ml	10mg/ml	10^{-1}	1000ug/ml	10ug
7	Gentamicin	10mg/ml	1ml	10mg/ml	10^{-1}	1000ug/ml	10ug
8	Streptomycin	100mg	10ml	10mg/ml	10^{-1}	1000ug/ml	10ug
9	Neomycin	500mg	16.7ml	30mg/ml	10^{-1}	3000ug/ml	30ug
10	Chloramphenicol	250mg	8.3ml	30mg/ml	10^{-1}	3000ug/ml	30ug
11	Tetracycline	250mg	8.3ml	30mg/ml	10^{-1}	3000ug/ml	30ug
12	Cotrimoxazole	480mg	19,2ml	25mg/ml	10^{-1}	2500ug/ml	25ug
13	Metronidazole	250mgmg	5mlml	50mg/ml	10^{-1}	5000ug/ml	50ug
14	Erythromycin	500mg	33.3ml	15mg/ml	10^{-1}	1500ug/ml	15ug
15	Azithromycin	500mg	33.3ml	15mg/ml	10^{-1}	1500mg/ml	15ug
16	Ciproxin	500mg	100ml	5mg/ml	10^{-1}	500ug/ml	5ug
17	Pefloxacin	400mg	80ml	5mg/ml	10^{-1}	500ug/ml	5ug
18	Oflaxacin	400mg	80ml	5mg/ml	10^{-1}	500ug/ml	5ug
19	Cephalexin	500mg	16.7ml	30mg/ml	10^{-1}	3000ug/ml	30ug
20	Cefuroxime (Zinnat)	500mg	16.7	30mg/ml	10^{-1}	3000ug/ml	30ug
21	Cefotaxime	500mg	16.7	30mg/ml	10^{-1}	3000ug/ml	30ug

The antimicrobial susceptibility testing was first carried out to determine the quality of the locally prepared antibiotics sensitivity disc from antibiotic tablets which was performed comparably with commercially obtained discs. Secondly, the sensitivity testing was carried out on the S. aureus isolates obtained from the primary school pupils from the study area. Antimicrobial susceptibility testing for isolates of S. aureus was determined by the Kirby-Bueur single disc agar diffusion method as recommended by the CLSI guidelines (CLSI, 2019) on Mueller-Hinton agar (Oxoid). Briefly, a sterilized wire loop was used to transfer 3-5 isolated colonies from the plate into a bijou bottle containing about 4ml of physiological saline. The colonies were emulsified in the normal saline to obtain a homogenous suspension of the bacterial cells. The turbidity of the suspension was adjusted visually to that of 0.5 McFarland Standard by adding sterile physiological saline to the suspension and was used as the inoculum (Cheesbrough, 2000). Thereafter, a sterile swab stick was dipped in the standardized inoculum in a bijou bottle removing excess fluid from the swab by pressing it against the side of the bottle. The surfaces of two Mueller Hinton agar plate previously dried in an incubator were streaked with the swab. The plates were left on the bench for about 20 minutes. The commercially prepared antimicrobial discs (Oxoid single disc) were aseptically placed on one of the inoculated plates while the locally prepared disc was placed on the other. Each disc was gently pressed on the agar surface using a sterilized forceps to ensure proper contact. Plates were inverted within 30 minutes of applying the discs and incubated at 37oc for 24 hours. The diameter of the zone of inhibition around each disc was measured in millimeter (mm) using a plastic transparent ruler according to guidelines for the interpretation of susceptibility categories (CLSI, 2019). When it was observed that the zones of inhibition in the locally prepared antibiotics were comparable with those observed from discs procured commercially, the same procedure was carried out on all the S. aureus isolates using twenty-one (21) antibiotics impregnated disc prepared locally.

2.9. Antibiogram typing using Ajumali's method of mnemonic coding

The 21 antibiotics were placed into seven different groups of 3 antibiotics, each according to their mode of action, family, usage and molecular weight arranged in ascending order of their molecular weight (Orhue, 2012). The Ajumali's mnemonic coding was used for the differentiation of strains as previously reported by Orhue (2016). The sensitive result was scored as (+), while resistance was recorded as (-). The three antibiotics in each group were given arbitrary numerical values of 1, 2, and 4. A perfect sensitivity to the three antibiotics gave a summation of 1+2 +4 = 7 while a complete resistance to the three antibiotics gave a summation of 0+0 +0 is = 0. Other values were obtained by adding up these numerical values; in this case, an isolate can receive a score of 0 - 7 in each triplet segment. Combining the seven-triplet segments together gave a seven-digit numerical value as the antibiogram type.

2.10 Data analysis

Statistical Package for Social Sciences (SPSS version 20) was used for data analysis and the results were presented in simple descriptive statistics of frequencies and percentages. Bar and pie charts as well as tables were used for presentation of results.

3. Results

In this study, 151 pupils were enrolled from 3 schools in 3 different communities within the Abuja metropolis. Of these, 62 (41.1%) were males and 89 (58.9%) were females. A total of 69 pupils yielded significant growth of *S. aureus* and thus the carriership rate of 45.7%. More positive samples were obtained from the females, 26.5% while the males had 19.2% (Table 2).

Table 2: Distributions of the pupils of different schools and positive cultures according to gender

Sample Source	No. of pupils enrolled	No. of males sampled	No. of females sampled	No positive	Males	Females
1st school	45(29.8%)	17(37.8%)	28(62.2%)	19(42.2%)	8(17.8%)	11(24.4%)
2nd school	52(34.4%)	21(40.4%)	31(59.6%)	28(53.9%)	12(23.1%)	16(30.8%)
3rd school	54(35.8%)	24(44.4%)	30(55.6%)	22(40.7%)	9(16.7%)	13(24.1%)
Total	151(100%)	62(41.1%)	89(58.9%)	69(45.7%)	29(19.2%)	40(26.5%)

Age group 11-12 had the highest carriership rate of 51.7% and this was followed by the pupils within ages 8-10 (44.4%) and 5-7 (43.9%). In comparison however, there was no significant difference (p = 0.71) in these rates recorded between the different age groups (Figure 1).

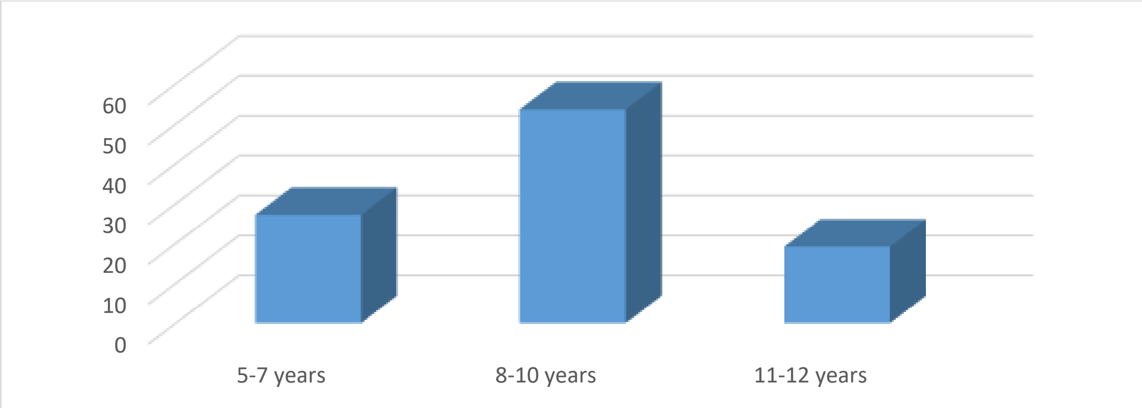

Figure 1: Distribution of *S. aureus* carriage according to the age of the pupils.

Table 3 showed the sensitivity pattern of isolates of *S. aureus* against 21 panels of antibiotics in the study area. Antibiotics with the highest sensitivity were Augmentine (87.0%), Cefotaxime (85.5%), oflaxacin (79.7%), Gentamicin (76.8%) and Cefuroxime (70.0%) while the least sensitive antibiotics were Ampicillin (10.1%), Amoxicillin (11.6%), Tetracycline (13.0%), Metronidazole (17.4%), and Ampiclox (18.4%).

Table 3. Sensitivity pattern of *S. aureus* isolate to different antibiotics

Antibiotics	Frequency	Susceptibility rate
Ampicillin	7/69	10.1%
Amoxicillin	8/69	11.6%
Ampiclox	13/69	18.4%
Unasyn	45/69	65.2%
Augmentin	60/69	87.0%
Floxapen	48/69	69.6%
Gentamicin	53/69	76.8%
Streptomycin	34/69	49.3%
Neomycin	29/69	42.0%
Chloramphenicol	17/69	24.6%
Tetracycline	9/69	13.0%
Cotrimoxazole	18/69	26.1%
Metronidazole	12/69	17.4%
Erythromycin	21/69	30.4%
Azithromycin	18/69	26.1%
Ciproxin	24/69	35.0%
Pefloxacin	30/69	43.5%
Oflaxacin	55/69	79.7%
Cephalexin	23/69	32.0%
Cefuroxime (Zinnat)	48/69	70.0%
Cefotaxime	59/69	85.5%

Figure 2 shows the isolates' cumulative susceptibility frequency to the different antibiotics classes. The aminoglycosides (29%) have the highest sensitivities, followed by beta-lactams (22%), Cephalosporins (18%) and Fluoroquinolones (16%), while the penicillin group (2%), Tetracyclin (6%) and Macrolides (7%) presented the least activities.

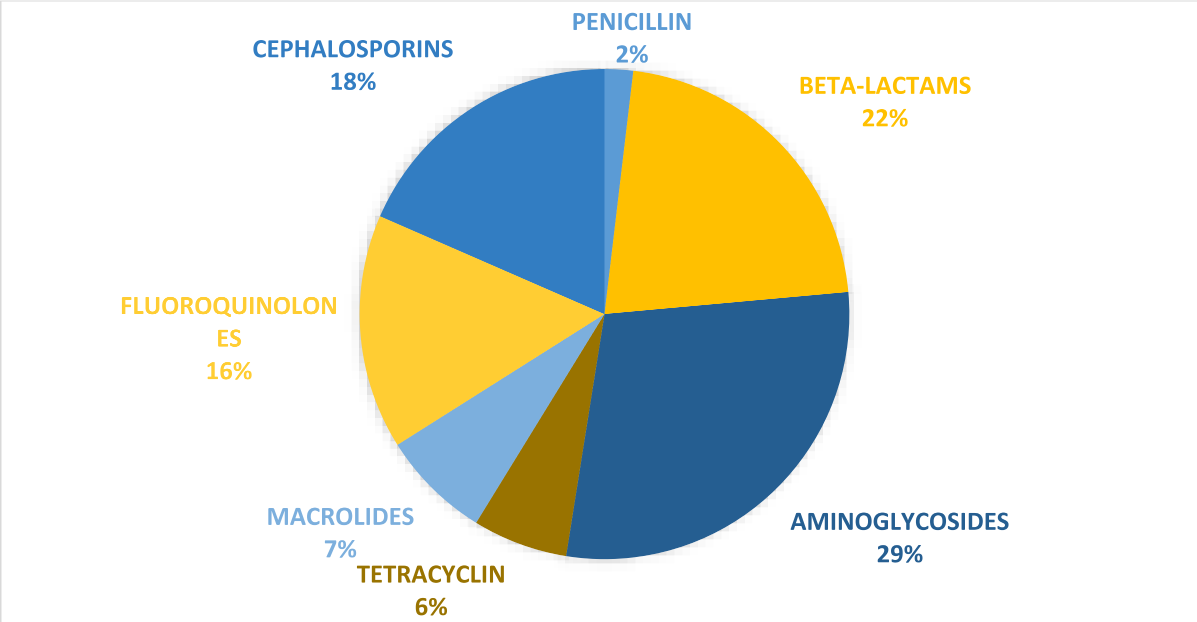

Figure 2: Cumulative frequency of susceptibility *of S. aureus* to different classes of antibiotics

Table 4 presents the multi-drug resistance (MDR) pattern of the isolated *S. aureus* to different classes of antibiotics. Overall, 30.4% of the isolated *S. aureus* were MDR with 21.7% resistance to 3 classes of antibiotics and 4.3%, 2.9% and 1.5% resistant to 4, 5 and 6 classes of antibiotics. The Ajumali's coding of the MDR isolates showed unique coding for the different levels of resistant isolates with only a pair of similar codes in the isolates resistant to 3 classes of antibiotics.

Table 4. Multi-drug resistance (MDR) pattern of *S. aureus* to different classes of antibiotics

No. of classes resistance to	Frequency	Percentage	Ajumali's codes
3 classes	15	21.7%	0260460 0730077* 0750076 0700276 0270240 0730077* 0050255 0070335 0700256 0230066 0005244 0636004 2300044 2360005 0720704
4 classes	3	4.3%	0700014 0450006 0601006
5 classes	2	2.9%	0200020 0200006
6 classes	1	1.5%	0200000
7 classes	0	0	------
Total	21	30.4%	

4.Discussion

Community and healthcare environments as well as households, prisons, public transportation, markets and places of worship play essential roles in *S. aureus* transmissions (Mork *et al*., 2019). Other confirmed risk factors for *S. aureus* colonization are HIV infection, infrequent hand washing, rural dwelling, and hospitalization (Ateba et al., 2012). Hence, the need to determine the prevalence and antibiotic sensitivity pattern of nasal *S. aureus* carriership in a growing population City like Abuja, the Nigeria Capital City.

In the present study, 390 questionnaires were distributed to three primary schools in three different communities in Abuja City. Of these questionnaires, 209 were returned, and 151 parents/guardians gave consent for their children to participate in the study. This is due to the misconception about COVID-19 and the numerous conspiracy theories about compulsory vaccination. This is because the mode of sample collection for *S. aureus* examination is similar to that of COVID-19, hence, most parent declined their children/ward participation since it was voluntary. The 151 primary school pupils aged five to twelve were enrolled. The total prevalence rate of *S. aureus* was 45.7%, with males representing 19.2% and females 26.5%. This high carriership rate further supported the fact that anterior nares remain a major reservoir of *S. aureus* as previously reported by Oparaodu et al. (2021). The observed prevalence of *S. aureus* colonization in the present study is similar to previous findings in Edo State, Nigeria (Orhue and Momoh, 2012; Akerele et al., 2015), but lower compared to the 69% reported by Ugwu et al. (2016). Onaolapo (2016) has also recorded incidence of *S. aureus* as high as 50.7% among school pupils. This high prevalence may be attributed to the site of sample collection considering that school environment is a risk factor for distributions of *S. aureus*. In line with this assertion, Al-Haj *et al*. (2017) has attributed the high prevalence *S. aureus* in school environment to be due to pupils different social and economic backgrounds. Another possible explanation for this high prevalence can be seen in Onaolapo (2016) who reported that the high prevalence may be due to occasion overcrowded classes that can enhanced the spread through inanimate objects like door handles and lockers. According to Garoy et al. (2019), this high rates of *S. aureus* infection could cause challenge for children by interrupting their school activities due to absenteeism and a challenge to the country because of lost productivity and school attendance as well as economic cost of treatment.

The observed higher prevalence of nasal carriership of *S. aureus* in female compared to male in this study is in accordance with the study by Hsu et al. (2020) who documented higher prevalent rate in female in Taiwan. Compared to the male counterpart in this study, a study had reported slightly high carriership rate among the males with a prevalence of 20.4% (Nagi et al., 2018). The high prevalence of nasal carriership of *S. aureus* in this study may be due to the age group within the study as the highest prevalence rate of *S. aureus* was 51.7% for ages 11-12. This is in line considering the fact by Shetty et al. (2014) that the prevalence of *S. aureus* is age dependent with peak colonization seen at age 7-15. This is contrary to a study on children aged between 1-6 that recorded 35% prevalence rate of *S. aureus* nasal carrieship and documented that nasal carriership decreases with ages beyond two years (Dey *et al.*, 2013). This age relationship might be due to lower sanitary standards, co-colonization with other pathogens or poor living conditions, such as large family sizes according to Lewnard *et al.* (2016).

The nasal carriership of *S. aureus* is one of the sources of infection both in the community and the hospital environment; with concomitant high resistance to most of the existing antimicrobial agents (Asif et al., 2019). In the present study, twenty-one panels of antibiotics were used for the antibiogram typing of *S. aureus* isolates and Augmentine (87.0%), Cefotaxime (85.5%), Gentamicin (76.8%) and Oflaxacin (79.7%) presented the highest sensitivity while Ampicillin (89.9%), Amoxicillin (88.4%), and Tetracycline (87.0%) were the most resistant antibiotics. In line with these findings, some other studies had reported high resistance to tetracycline (Adamu *et al.*, 2020, Adamu *et al.*, 2021) and other commonly used first line antibiotics in communities (Auta *et al*., 2019, Aliyu *et al*., 2020; Chukwu *et al.*, 2022). These antibiotics with high resistance are always accessible over the counter and unlicensed medicine stores. The pattern of resistance seen in this study reflected the magnitude of misuse of those commonly used antibiotics in the area. Also in agreement with this study, a study in Southeastern Nigeria in healthy school children had recorded low resistance to gentamicin and floroquinolones (Ugwu *et al*., 2016). This suggests that antibiotic misuse encourages the development of resistance as seen with the commonly used antibiotics. High susceptibility to Gentamicin and Ofloxacillin is probably the reason that they are not frequently used in children, more so, Gentamicin is available in injection, while oflaxicilin is new and very expensive and hence these agents are rarely used in children. The antibiotics by classification showed that the beta-lactams (24.2%) have the highest sensitivities, followed by Cephalosporins (20.6%) while the penicillin group (2.1%) had the least activities. According to Bissong *et al*. (2020), the unrestrained availability of the commonly used group of antibiotics over the years, has contributed to their misuse, which favours the high resistance rates identified in this study.

The multi-drug resistance strains were easily identified using the Ajumali's method of pneumonic coding by the appearance of the strains patterns. The incidence of multidrug resistance *S. aureus* in a community, will make treatment of common infections much more difficult (Van and Paterson, 2016). The frequency of multidrug resistance (30.4%) observed in this study is similar to that reported in a study by Omoshaba *et al.,* (2018) in Western part of Nigeria, but lower than that reported in south-south (Onanuga *et al.,* 2019) and northern (Onanuga *et al.*, 2021) parts of Nigeria and higher than that reported in China (Wang *et al*., 2022). Considering these differences, it is therefore necessary to study the antibiotic susceptibility patterns of *S. aureus* based on global geographic regions. This will enable researchers to better understand the organisms' new and emerging resistance trends, which will be useful for the management of both hospital and community-acquired infections.

In conclusion, the present study revealed that there is high prevalence of *S. aureus* that is highly resistance to commonly used antibiotics with potentials of multi-drug resistance among the primary school pupils within Abuja City. The outcomes suggest that these antibiotics could gradually be losing their therapeutic ability in the study area for treatment of *S. aureus* infection. It is therefore, critical for health institutions to imbibe good antibiotic stewardship and antibiogram practise prior to antibiotic therapy.

Use of AI tools declaration

We declare we have not used Artificial Intelligence tools in the writing or creation of this article.

Author contributions

POO: Study conceptualization, investigation, supervision, original draft review.

COJ: Investigation, data and sample collection, laboratory analysis, statistical analysis.

UA: Study conceptualization, investigation, statistical analysis, writing of first draft, review and editing.

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Conflict of interest

The authors of this work have no conflicting interest.

References

1. Abubakar U. (2020). Point prevalence survey of hospital acquired infections in three acute care hospitals in Northern Nigeria. *Antimicrobial Resistant Infection Control*, 9(63). https://doi.org/10.1186/s13756-020-00722-9
2. Adamu H., Njoku K., Olajide I., Ukonu W., Niyang M. (2020). Antimicrobial resistance pattern across two states in Nigeria- A descriptive/observational study. *International Journal of Infectious Diseases*, 101, 45. DOI:10.1016/j.ijid.2020.09.151
3. Adamu J.Y., Raufu A.I., Chimaroke F.C., Ameh J.A. (2021). Antimicrobial susceptibility testing of *Staphylococcus aureus* isolated from apparently healthy humans and animals in Maidugurii, Nigeria. *International Journal of Biomedical and Health Science*, 6(4). 191–195.Corpus ID: 88532871
4. Agbelade A.D., Onyekwelu J.C., Oyun M.B. (2017). Tree Species Richness, Diversity, and Vegetation Index for Federal Capital Territory, Abuja, Nigeria. *International Journal of Forestry Research,* 2, 12. https://doi.org/10.1155/2017/4549756
5. Ajoke O., Okeke I.O., Odeyemi O., Okwori A.E.J. (2012). Prevalence of Methicillin-Resistant *Staphylococcus aureus* from Healthy Community Individuals Volunteers in Jos South, Nigeria. *Journal of Microbiology, Biotechnology and Sciences*, 6(1), 1389–1405. https://office2.jmbfs.org/index.php/JMBFS/article/view/7217
6. Akerele J.O., Obasuyi O., Omede D. (2015). Prevalence of Methicillin-Resistant *Staphylococcus aureus* among Healthy Resisdents of Ekosodin Community in Benin-City, Nigeria. *Tropical Journal of Pharmaceutical Research,* 14(8), 1495-1499. DOI:10.4314/tjpr.v14i8.24
7. AL-Haj N.A, Hauter J.M, Al-Bulili N.H, Al-Hotami R.A, Al-Horaibi M.T. Nasal Carriage of

staphylococcus aureus Among Students of Public Schools in Sana'a, Yemen. *Research Journal of Microbiology*. 2017;13:65–69. https://scialert.net/abstract/?doi=jm.2018.65.69

8. Aliyu Y., Abdullahi I., Reuben R. (2021). Molecular typing and antibiotic susceptibility of methicillin-resistant *Staphylococcus aureus* in fresh milk and milk products in Nigeria. *International Journal of Infectious Diseases*, 101(S1), 8-119. DOI:10.1016/j.ijid.2020.09.150
9. Anowai C.O., Agarry O.O., Akin-Osanaiye B.C. (2018). Antibiotics Susceptibility Profile of *Staphylococcus aureus* isolated from Clinical Patients in Abuja, Nigeria. *Direct Research Journal of Health and Pharmacology*, 6(3), 19-26. https://www.wjrr.org/download_data/WJRR0901004.pdf
10. Ansari S., Gautam R., Shrestha S., Ansari S.R., Subedi S.N., Chetri M.R. (2016). Risk factors assessment for nasal colonization of *Staphylococcus aureus* and its methicillin resistant strains among pre-clinical medical students of Nepal. *BioMed Central Research Notes*. 9: 214. doi: 10.1186/s13104-016-2021-7
11. Asif A., Javed I., Mushtaq S., Anwar S. (2019). Staphylococcal Cassette Chromosome Mec Types in Nasally Carried Methicillin Resistant *Staphylococcus aureus* Isolates of Healthcare Workers in a Tertiary Care Hospital: A Cross-Sectional study. *Pakistan Postgraduate Medical Journal*, *30*(04), 142-146. DOI: https://doi.org/10.51642/ppmj.v30i04.565
12. Ateba N.U., Schaumburg F., Adegnika A.A. (2012). Epidemiology, and population Structure of *Staphylococcus aureus* in various population groups from a rural and semi urban area in Gabon, Central Africa.*Acta Tropica*, 124, 42-47. doi: 10.1016/j.actatropica.2012.06.005.
13. Auta A., Hadi M.A., Oga E., Adewuyi E.O., Abdu-Aguye S.N., Adeloye D., Strickland-Hodge B., Morgan D.J. (2019). Global access to antibiotics without prescription in community pharmacies: a systematic review and meta-analysis. *Journal of Infection*, *78*(1), 8-18. doi: 10.1016/j.jinf.2018.07.001
14. Bae S., Yu J.Y., Lee K., Lee S., Park B., Kang Y. (2012). Nasal colonization by four potential respiratory bacteria in healthy children attending kindergarten or elementary school in Seoul, Korean. *Journal of Medical Microbiology*, 61, 678–685. doi: 10.1099/jmm.0.040584-0.
15. Bissong M.E.A., Tahnteng B.F., Ateba C.N., Akoachere J.F.T.K. (2020). Pathogenic potential and antimicrobial resistance profile of *Staphylococcus aureus* in milk and beef from the Northwest and Southwest Regions of Cameroon. *BioMed Research International*, *2020*, 6015283. doi: 10.1155/2020/6015283
16. Charan J., Biswas T. (2013). 'How to calculate sample size for different study designs in medical research?'*Indian Journal of Psychological Medicine*; 35(2): 121–126. doi: 10.4103/0253-7176.116232
17. Cheesbrough M. (2000). District Laboratory Practice in Tropical Countries. Part 2: *Cambridge University Press.*
18. Chen Y., Liu Z., Duo L., Xiong J., Gong Y., Yang J., Wang Z., Wu X., Lu Z., Meng X., Zhao J., Zhang C., Wang F., Zhang Y., Zhang M., Han Li. (2014). Characterization of *Staphylococcus aureus* from Distinct Geographic Locations in China: An Increasing Prevalence of spa-t030 and SCCmec Type III. *PLoS ONE*, 9(4), e96255. doi: 10.1371/journal.pone.0096255
19. Chen Y.H., Huang K.A., Huang Y.C., Chi H., Lu C.Y., Chang L.Y., Ho Y.H., Chi C.Y., Liu C.C., Huang L.M., Yang T.Y.O., Huang Y. C. (2020). Prevalence and molecular characterizations of *Staphylococcus aureus* nasal colonization among patients in pediatric intensive care units in Taiwan. *Antimicrobial Resistance and Infection Control*, 9 (1): 41. doi: 10.1186/s13756-020-0700-6.
20. Chukwu E.E., Awoderu O.B., Enwuru C.A., Afocha E.E., Lawal G.R., Ahmed A.R., Olarenwaju I., Onwuamah C.K., Audu R.A., Ogunsola T.F. (2022). High prevalence of resistance to third-generation cephalosporins detected among clinical isolates from sentinel healthcare facilities in Lagos, Nigeria. *Antimicrobial Resistance & Infection Control,* 11 (1): 134. doi: 10.1186/s13756-022-01171-2.
21. Clinical and Laboratory Standards Institute (2019). Performance standards for antimicrobial susceptibility testing; twenty-ninth informational supplement. M100-S29. Wayne, PA: *Clinical and Laboratory Standards Institute*.
22. Dey S., Rosales-Klintz S., Shouche S., Pathak N PJ., Pathak A. (2013). Prevalence and risk factors for nasal carriage of *Staphylococcus aureus* in children attending anganwaries (preschools) in Ujjain, *India. BioMed Central research note*, 6, 265. doi: 10.1186/1756-0500-6-265
23. Doaa E., Salwa A.E. (2012). Identification of *Staphylococcus aureus* and Escherichia coli isolated from Egyptian food by conventional and molecular methods, *Journal of Genetic Engineering and Biotechnology*, 10(10), 129-135. DOI:10.1016/j.jgeb.2012.01.004
24. Eibach D., Nagel M., Hogan B., Azuure C., Krumkamp R., Dekker D., Gajdiss M., Brunke M.

Sarpong N., Owusu-Dabo N., May J. (2017). Nasal carriage of *Staphylococcus aureus* among children in the Ashanti region of Ghana. *PLoS ONE*, 12(1), 1–11. doi: 10.1371/journal.pone.0170320.

25. Garoy E.Y., Gebreab Y.B., Achila O.O., Tekeste D.G., Kesete R., Ghirmay R., Kiflay R., Tesfu T. (2019). Methicillin-Resistant *Staphylococcus aureus* (MRSA): Prevalence and Antimicrobial Sensitivity Pattern among Patients-A Multicenter Study in Asmara, Eritrea. *The Canadian Journal of Infectious Diseases & Medical Microbiology*, 8321834. doi: 10.1155/2019/8321834.
26. Godwin E. (2022). Prevalence and Characterization of Staphylococci from Dried Crayfish in Selected Markets in FCT, Abuja, Nigeria. *EC Veterinary Science*, *7 (6):* 30-41.
27. Goel A, Garima, Aggarwal N, et al. (2023). Skin and Soft Tissue Infections: Current Advancement in Epidemiology, Pathogenesis and Management. *Journal of Pure & Applied Microbiology*. 17(1):89-111. https://doi.org/10.22207/JPAM.17.1.50
28. Habeeb A., Hussein N.R., Assafi M.S., Al-Dabbagh S.A. (2014). Methicillin resistant *Staphylococcus aureus* nasal colonization among secondary school students at Duhok city-Iraq. *Journal of Microbiology Infectious Disease*, 4(2), 59–63. https://doi.org/10.5799/ahinjs.02.2014.02.0128
29. Hsu Y.Y., Wu D., Hung C.C. Huang S.S., Yuan F.H., Lee H.M., Huang C.T., Shie S.S., Huang P.O., Yang C.C., Cheng C.W., Leu H.S., Wu T.S., Huang Y.C. (2020). Methicillin-resistant *Staphylococcus aureus* nasal colonization among HIV-infected patients in Taiwan: prevalence, molecular characteristics and associated factors with nasal carriage, *BioMed Central Infection & Diseases*, 20, 254. doi: 10.1186/s12879-020-04979-8
30. Jourdain S., Smeesters P., Denis O., Dramaix M., Sputael V., Malaviolle X. (2011): Differences in nasopharyngeal bacterial carriage in preschool children from different socio-economic origins. *Clinical Microbiology and Infection*, 17 (6): 907–1014. doi: 10.1111/j.1469-0691.2010.03410.x.
31. Lewnard J.A., Givon-Lavi N., Huppert A., Pettigrew M.M., Regev-Yochay G., Dagan R. (2016): Epidemiological markers for interactions among *Streptococcus pneumoniae*, *Haemophilus influenzae, and Staphylococcus aureus* in upper respiratory tract carriage. *Journal of Infectious Diseases*, 213(10), 1596-1605. doi: 10.1093/infdis/jiv761.
32. Linz MS., Mattappallil A., Finkel D., Parker D. (2023). Clinical Impact of *Staphylococcus aureus* Skin and Soft Tissue Infections. *Antibiotics*, *12*(3), 557; https://doi.org/10.3390/antibiotics12030557
33. Mork R.L., Hogan P.G., Muenks C.E., Boyle M.G., Thompson R.M., Sullivan M.L., Morelli J.J., Seigel J., Orschein R., Wardenburg J.B., Gehlert S., Burnham C., Rzhetsky A., Fritz S.A. (2020). Longitudinal, strain-specific *Staphylococcus aureus* introduction and transmission events in households of children with community-associated meticillin-resistant *S. aureus* skin and soft tissue infection: a prospective cohort study. *The Lancet Infectious Diseases*, *20*(2), 188-198. doi: 10.1016/S1473-3099(19)30570-5
34. Nagi A.A., Jawaher M.H., Noria H.A., Rasha A.A., Maha T.A. (2018). Nasal Carriage of *Staphylococcus aureus* Among Students of Public Schools in Sana'a, Yemen. *Research Journal of Microbiology*, 13, 65-69. URL: https://scialert.net/abstract/?doi=jm.2018.65.69
35. Neupane K., Rayamajhee B., Acharya J., Rijal N., Shrestha D., Binod GC., Pant, M.R., Shah P.K. (2018). Comparison of Nasal Colonization of Methicillin-Resistant *Staphylococcus aureus* in HIV-Infected and Non-HIV Patients Attending the National Public Health Laboratory of Central Nepal. *The Canadian Journal of Infectious Diseases & Medical Microbiology*, 4508757. doi: 10.1155/2018/4508757
36. Nsofor C., Nwokenkwo N., Nwaokpa C. (2015). Nasal carriage of *Staphylococcus aureus* among apparently healthy school children in Owerri metropolis, Nigeria. *Med Crave Online Journal of cell Science & Report*, 1(2), 117-120. DOI: 10.15406/mojcsr.2015.02.00038
37. Oke M.A., Bello A.B., Odebisi M.B., El-Imam A.A., Kazeem, M.O. (2013). Evaluation of antibacterial efficacy of some alcohol-based hand sanitizers sold in Ilorin (North-Central Nigeria). *Ife Journal of Science*, *15*(1), 111-117. https://www.ajol.info/index.php/ijs/article/view/131391
38. Omoshaba E.O., Ojo O.E., Sofela O., Onifade O.I. (2018). "Prevalence and antibiotic resistance patterns of methicillin-resistant *Staphylococcus aureus* in raw milk and soft cheese (wara) sold in Abeokuta, Nigeria," Sokoto. *Journal of Veterinary Sciences*. 16(1), 3–6. DOI:10.4314/sokjvs.v16i1.1
39. Onanuga A, Eboh D.D, Okou G.T. Antibiogram and Virulence Characteristics of Multi-drug Resistant *Staphylococcus aureus* from Nasal Cavity of Healthy Students of Niger Delta

University, Amassoma, Bayelsa State, Nigeria. *Journal of Clinical and Diagnostic Research*. 2019;13(7):DC24–DC29. https://doi.org/10.7860/JCDR/2019/41396.13031

40. Onanuga A., Adamu OJ., Odetoyin B., Hamza AJ. Nasal carriage of multi-drug resistant panton valentine leukocidin positive *staphylococcus aureus* in healthy individuals of Tudun-wada, Gombe State, Nigeria. *Afr J Infect Dis.* 2021; 15(1): 24–33. doi: 10.21010/ajid.v15i1.3
41. Onaolapo JA, Afolabi OE and Igwe JC (2016). Incidence of Antibiotic Susceptibility Profile of *Staphylococcus aureus* on Door Handles in Ahmadu Bello University, Zaria. *Journal of Tropical Diseases and Public Health*, 4(1), 48.
42. Oparaodu, U., N. N. Odu, and G. A. Uzah. 2021. "Antibiogram of Methicillin Resistant Staphyloccocus Aureus Solated from Nasal Carriage of Some University Students of Rivers State University, Port Harcourt, Nigeria". *Journal of Advances in Medicine and Medical Research* 33 (15):73-81. https://doi.org/10.9734/jammr/2021/v33i1530988.
43. Orhue O.P. (2016). Analysis of Antibiotic Resistivity Pattern of *Escherichia coli* Isolated from Clinical Samples in Auchi Township Area, Edo State, Nigeria. *International Journal of Biosciences and Technology*, 9(3), 15-23.
44. Orhue P.O. (2012). The antibiogram types of *Staphylococcus aureus* isolated from nasal carriers from Irrua Specialist teaching hospital, Edo state, Nigeria. *E3 Journal of Biotechnology and Pharmaceutical Research*, 3(4):83-87.
45. Pathak A., Yogyata M., Iyer R.V., Singh B., Sharma M., Eriksson B., Macaden R., Stalsby C.L., (2010). Nasal carriage and antimicrobial susceptibility of *Staphylococcus saureus* in healthy preschool children in Ujjain, India. *BioMed Central Pediatrics*, 10, 100. doi: 10.1186/1471-2431-10-100.
46. Rasamiravaka T., Rasoanandrasana S., Zafindraibe N.J., Rakoto-Alson A.O., Rasamindrakotroka A. (2013). Evaluation of methicillin-resistant *Staphylococcus aureus* nasal carriage in Malagasy patients. *Journal of Infection in Developing Countries*, 7 (4): 318-322. doi: 10.3855/jidc.2460.
47. Schmidt A., Bénard S., Cyr S. (2015). Hospital cost of staphylococcal infection after Cardio thoracic or orthopedic operations in France: a retrospective database analysis. *Surgical Infections*, 16 (4): 428–435. doi: 10.1089/sur.2014.045
48. Sedighi I., Moez H.J., Alikhani M.Y. (2011). Nasal carriage of methicillin resistant *Staphylococcus aureus* and their antibiotic susceptibility patterns in children attending day-care centers. *Acta Microbiologica et Immunologica Hungarica*, *58* (3), 227–234. doi: 10.1556/AMicr.58.2011.3.6.
49. Shetty V., Trumbull K., Hegde A., Shenoy V., Prabhu R., Palavecino E., Shetty A.K. (2014). Prevalence of Community-Acquired Methicillin-Resistant *Staphylococcus aureus* Nasal Colonization among Children. *Journal of Clinical and Diagnostic Research*, 8(12), 12–15. DOI:10.7860/JCDR/2014/9986.5276
50. Tran K.Q., Nguyen T.T.D., Pham V.H., Pham Q.M., Tran H.D. (2023). Pathogenic Role and Antibiotic Resistance of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Strains Causing Severe Community Acquired Pneumonia in Vietnamese Children. *Advances in Respiratory. Medicine*, 91, 135–145. https://doi.org/10.3390/arm91020012
51. Tuta K.E., Okesola A.O., Umeokonkwo C.D. (2019). The Prevalence and Risk Factors Associated with Nasal Methicillin-Resistant *Staphylococcus Aureus* Colonization among Children in a Tertiary Hospital in Nigeria. *Ethiopian Journal of Health Sciences*, *29*(4), 487–494. doi: 10.4314/ejhs.v29i4.10
52. Ugwu M.C., Anie C.O., Ibezim E.C., Esimone C.O. (2016). Antimicrobial Evaluation of Methicillin Resistant *Staphylococcus aureus* Nasal Carriage amongst Healthy Students in Agbor, Delta State, Nigeria. *Archives of Clinical Microbiology*, 7(2), 13. https://api.semanticscholar.org/CorpusID:51959760
53. United Nations-World Population Prospects (2021). Abuja, Nigeria Metro Area Population 1950-2021. https://www.macrotrends.net
54. Usman A., Syed A.S.S. (2018). Prevalence, trend, and antimicrobial susceptibility of Methicillin Resistant *Staphylococcus aureus* in Nigeria: a systematic review. *Journal of Infection and Public Health*, 763-770. doi: 10.1016/j.jiph.2018.05.013.
55. Van Duin D., Paterson D.L. (2016). Multidrug-resistant bacteria in the community: trends and lessons learned. *Infect Dis Clin North Am.; 30*(2), 377-390. doi: 10.1016/j.idc.2016.02.004.
56. Wang H., Wu D., Di L., Zhu F., Wang Z., Sun L. Chen Y., Jiang S., Zhuang H., Chen M., Ji S., Chen Y. (2022). Genetic Characteristics of Multiple Copies of Tn1546-Like Elements in ermB-Positive Methicillin-Resistant

Staphylococcus aureus from Mainland China. *Frontiers in Microbiology*, *13*. https://doi.org/10.3389/fmicb.2022.814062

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