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Phenotypic Characterization of Methicillin-Resistant *Staphylococci* Isolated from Wounds and Nasal Swabs in Selected Hospitals across some Northwestern States, Nigeria

[*1]Ajagbe, J. M. , [2]Kumurya, A. S., [3]Dutsinma, U. A. and [4]Ega, B. and [5]Binta, L. B. and [6]Bitet, D. E.

[1]Department of Medical Laboratory Science, School of Health Technology, Kankia, Katsina State, Nigeria

[2]Department of Medical Laboratory Science, Bayero University, Kano, Nigeria

[3]Department of Microbiology, Bayero University, Kano, Nigeria

[4]Department of Medical Microbiology, Ahmadu Bello University Teaching Hospital, Shika, Zaria, Nigeria

[5]Department of Medical Laboratory Science, School of Health Technology, Kankia, Katsina State, Nigeria

[6]Rural Hospital Kwoi, Ministry of Health, Kaduna State, Nigeria

Correspondence: josephajagbe918@gmail.com

Abstract

Methicillin-resistant Staphylococci (MRS) remain important opportunistic pathogens most frequently identified worldwide. The study aimed to determine the phenotypic characteristics of Methicillin-resistant Staphylococci, their antibiotic susceptibility patterns, and the socio-demographic characteristics of the isolates from wounds and nasal swabs in selected hospitals across some states in Northwestern Nigeria. A total of 806 wounds and nasal swabs were collected from patients admitted at nine facilities in 4 states of Northwestern Nigeria. All samples underwent analysis using standard bacteriological techniques. Antibiotic susceptibility testing (AST) was conducted using the Kirby-Bauer technique. Out of 806 samples, 652 (80.3%) were culture positive, while 154 (19.1%) were culture negative. A total of 704 (87.3%) isolates were obtained, out of which 418 (59.4%) were identified as Staphylococci isolates, comprising 144 (17.7%) Methicillin-resistant Staphylococcus aureus (MRSA), 124 (15.4%) Methicillin-susceptible Staphylococcus aureus (MSSA), 89 (11%) Methicillin-resistant coagulase-negative Staphylococci (MRCoNS), and 61 (7.6%) Methicillin susceptible coagulase-negative Staphylococci (MSCoNS). The Staphylococci isolates showed the highest susceptibility to Vancomycin 408 (97.6%), while the lowest was penicillin 24 (5.7%). The isolation rate of MRS was highest among patients aged 11-30, while the 71-90 age group had the lowest rate. The occurrence was higher (37%) in male patients than in female patients (18.6%). Moreover, there was no statistically significant association found between the distribution of MRS among different age groups, gender, and occupational affiliations, but it exists in the educational levels, and economic statuses of the research participants. The occurrence of MRS was lower among patients with a high level of formal education but higher among those without or with a low level of education. These findings will aid healthcare workers in establishing policies for antibiotic usage, surveillance, and infection prevention and control measures.

Keywords: Methicillin-resistant Staphylococci, northwestern Nigeria, Wounds, nasal swabs.

INTRODUCTION

Over time, *Staphylococci* have developed resistance to penicillin-related antibiotics, including methicillin, and are known as Methicillin-resistant *Staphylococci* (Schulman, 2023). Methicillin-resistant *Staphylococci* remains an important opportunistic pathogen most frequently identified worldwide (Borg and Camilleri, 2021). With the emergence of Methicillin-Resistant *Staphylococcus aureus* (MRSA), the pathogenicity of *S. aureus* has become a problem in both health institutions and community settings. MRSA infection has been on the rise since its discovery in the early 60s, although there has been a decline in European Countries (ECDC, 2019). *Staphylococcus aureus* is the causative agent of abscesses, lung infections, bacteremia, endocarditis, and osteomyelitis in humans (Tong *et al.*, 2015).

MRSA is any strain of *S. aureus* that has emerged through horizontal gene transfer and natural selection, which results in multiple drug resistance to beta-lactam antibiotics (Gurusamy *et al.*, 2013). Methicillin resistance is induced by the *mecA* gene, which is located on the *staphylococcal* cassette chromosome *mec* (SCC*mec*), a large heterologous genetic element encoding a low-affinity penicillin-binding protein 2a (PBP2a), which inhibits the activity of ß-lactam antibiotics (Han *et al.*, 2012). The increasing prevalence of MRSA complicates the treatment and management of staphylococcal infections (Duran *et al.*, 2012). Methicillin-resistant *Staphylococci* (MRS), linked with hospitals and long-term care facilities, is now isolated in the community. Since the first discovery of MRSA in 1961, only 1 year after the introduction of methicillin, MRSA has become one of the most predominant pathogens causing nosocomial infections (Ma *et al.*, 2002). Methicillin, a semisynthetic penicillin poorly hydrolyzed by penicillase, was first used clinically in 1960. After one year, *S. aureus* strains that displayed resistance to methicillin were reported (Jevons, 1961). Subsequently, MRSA strains have appeared in countries worldwide and continue to be one of the most common hospital pathogens (Ayliffe, 1997). Data available was from a study by Nas *et al.* (2018) on phenotypic characterization and characterization of antibiotic susceptibility pattern of MRSA in some tertiary Hospitals in Kano. A prevalence of 15% was reported. Another study by Sunusi *et al.* (2023) reported 12.6% in phenotypic identification of MRSA isolated from surfaces of public Hospitals in Katsina State. However, Dangari *et al.* (2024) obtained a higher prevalence of 63% MRSA from clinical samples in some selected Hospitals in Dutsinma and Kurfi Local Government Area, Katsina. A 30.3% MRSA prevalence was stated by Hassan *et al.* (2021) via phenotypic method in a research titled Prevalence and susceptibility pattern of *Staphylococcus aureus* in locally pasteurized cow milk sold at Dutse metropolis, Jigawa State. There is a paucity of data on recent studies related to *Staphylococci* in clinical samples from Jigawa State. In Kaduna State, a prevalence of 7.8% was reported by Umaru *et al.* (2019), while 4.8% by Gali *et al.* (2013) also from Kaduna State by phenotypic method.

Nevertheless, there is little information about previous and recent research on bacteriological studies of MRS isolates in some states of Northwestern Nigeria. The study is expected to serve as a reference material for future research in the important aspect of bacteriological studies on methicillin-resistant *Staphylococci*. This research was carried out to phenotypically characterize Methicillin Resistance *Staphylococci* isolated from wounds and nasal swabs in some states of northwestern Nigeria. Therefore, the research among critically ill patients in some states of northwestern Nigeria's health Institutions goes a long way, greatly impacting patient care, infection control, and the need to establish antimicrobial stewardship in the facilities.

MATERIALS AND METHODS

Study Population

The study population consisted of 403 patients with wounds admitted to the Male, Female, and Children wards of 9 tertiary and specialist health institutions in several states of Northwestern Nigeria. The rationale for selecting participating institutions is that the Institution must be a tertiary or specialist healthcare institution located within the northwestern region. The health institutions were four (4) Teaching Hospitals, one (1) Federal Medical Center, two (2) Orthopedic Hospitals, and two (2) Specialist Hospitals. The Teaching Hospitals are Aminu Kano Teaching Hospital (AKTH) and Abdullahi Wase Teaching Hospital in Kano; Ahmadu Bello University Teaching Hospital (ABUTH) at Zaria, Kaduna state; and Federal Teaching Hospital in Katsina. While the Federal Medical Center includes, Federal Medical Centre Birnin Kudu (FMCBK), located at Jigawa State. The Orthopedic Hospitals include National Orthopedic Hospital, Dala, Kano, and General Amadi Rimi Specialist Hospital. The Specialist Hospitals are Murtala Mohammed Specialist Hospital (MMSH), Kano, and Rasheed Shekoni Specialist Hospital Dutse, located in Kano and Jigawa States respectively.

Inclusion Criteria

The inclusion criteria in this research were male and female patients less than 1 to 80 years with septic wounds who were hospitalized at tertiary health institutions in Northwestern Nigeria and had provided their consent.

Exclusion Criteria

The exclusion criteria for this research, on the other hand, included male and female patients who did not consent, patients with clean wounds or without wounds, and those treated at the Outpatient Departments of the hospitals.

Sample Size Determination

The sample size for the study was determined using the standard epidemiological formulae by Naing *et al*. (2006) as follows:

$$n = \frac{Z^2 p (1-p)}{d^2}$$

Where,

n = Sample size

Z = Statistic for the level of confidence at 95% = 1.96

p = Prevalence in similar work

q = 1-p

d = Degree of accuracy = 5% (0.05)

Therefore, in this study, P = 48.5% (Aminu *et al*., 2017)

q = 1-0.485 = 0.515

Substituting,

$$n = \frac{(1.96)^2 (0.48) (0.51)}{(0.05)^2}$$

$$= \frac{(3.84) (0.48) (0.51)}{(0.0025)}$$

n = 376.

Therefore, a total of 403 patients were included in this study each patient providing duplicate clinical samples (wound and nasal swabs).

Ethical Considerations

The protocol for this study was submitt**ed** to the Ethics and research committee of the tertiary and specialist health i**nstitutions** in various states of Northwestern **Nigeria**, and approval was obtained before commencing the research. As a result, an adequate level of confidentiality of research data was ensured. Informed consent was obtained from all participants before specimen collection.

Sample Collection and Transportation

The patients were recruited from the population of health institutions in some states of northwestern Nigeria using a simple random sampling technique. A total of 806 samples were collected from the nasal orifice and different wound types (soft tissue, burns, surgical, ulcer, and osteomyelitis) of patients from male, female, and children wards from the 9health care institutions in 4 states of northwestern Nigeria, over a period of 18 months. Sterile cotton swabs moistened in sterile peptone water were used. Two swabs (one for the wound and the other for) the nose, were applied and slowly rotated, thoroughly covering the surface of the wound and nose, respectively. These swabs were inserted into Amies transport medium and placed in an ice pack at the bottom of a secure leak-proof cold box. The clinical samples were appropriately labeled with a laboratory identification number and conveyed to the laboratory for analysis. After collection, additional information about patients, including age, sex, the onset of lesion, previous antibiotic intake, and type, were recorded on the questionnaire. It was ensured that the laboratory identification number of each sample corresponded with the questionnaire number for each patient (Ghanbari *et al*., 2017). Immediately after the clinical samples were collected, they were properly labeled and placed in Amies transport media, which was then capped securely. All samples were promptly transported to the facility laboratory for primary isolation using the appropriate media. Subsequently, the clinical isolates were transferred to the Department of Microbiology at Aminu Kano Teaching Hospital in Kano State for phenotypic characterization, which included culture, microscopy, biochemical identification, and antimicrobial susceptibility testing.

Microbiological Analysis

As soon as the clinical samples arrived at the laboratory, they were processed using standard microbiological techniques, including culture, microscopy, and biochemical phenotypic identification. Control organisms, such as the American Type Culture Collection (ATCC) strains ATCC25923 and ATCC43300 of *S. aureus* from Manassas, Virginia, USA, were utilized for each test run.

Cultures and Biochemical tests

The samples and control strains of *S. aureus* were inoculated directly on sheep's blood agar and mannitol salt agar (MSA) plates, then incubated at 35°C for 18-24 hours in an aerobic atmosphere. Subsequently, the colonies on MSA plates were sub-cultured on fresh plates and further incubated for 24 hours to obtain discrete colonies of *Staphylococci* species. Staphylococcus species were identified based on their morphological and biochemical characteristics using Gram's stain reaction, catalase, coagulase, mannitol fermentation and DNAse tests (Ochei and Kolhatkar, 2000; Baker and Silverton, 2000; Chessbrough, 2002; Tankeshwar, 2022; Kumurya, 2015;).

Antimicrobial Susceptibility Testing

Antibiotic susceptibility testing was conducted using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar. Each isolates previously identified as *Staphylococci* underwent antibiotic profiling following the method recommended by the Clinical Laboratory Standard Institution (Clinical Laboratory Standard Institution, CLSI, 2016). Discrete colonies of isolates on MSA plates were emulsified in 3 – 4 ml of sterile physiological saline, and the turbidity was adjusted to 0.5 McFarland Standard (Approximately a cell density of 1.5 x 10^8 cfu/ml) (CLSI, 2016).

McFarland turbidity standards serve as a reference to adjust the turbidity of bacterial suspensions, ensuring that the bacterial count falls within a specified range for standardizing microbial testing. To prepare a 0.5 McFarland standard, 0.05ml of 1.175% Barium chloride dehydrate (BaCl2.2H20) was mixed with 9.95ml of 1% tetraoxosulphate (vi) acid (H_2SO_4). This standard was visually compared to a bacterial suspension in sterile saline (Cockerill, 2012).

The inoculum was prepared by obtaining a fresh, pure culture of the bacterial isolate using a sterile wire loop and inoculating it in sterile normal saline. Under good lighting, a visual comparison of the test organism suspension with the McFarland turbidity standard was made by comparing the lines on a Wickerham card. If the test suspension was too light, additional bacterial isolate was added until the turbidity matched the standards. If the test suspension was too thick, sterile pipettes were used to add normal saline to achieve the desired turbidity (McFarland, 1907). Using sterile swab sticks, the surface of Mueller Hinton Agar (MHA) in a 90mm diameter plate was inoculated with the bacterial suspension by streaking the agar surface in three directions and rotating the plate approximately 60^0 to ensure even distribution.

The inoculated plates were allowed to dry for 10 minutes before antibiotic discs including Oxacillin (5µg), Vancomycin (30µg), Gentamycin (10µg), Clindamycin (30µg), Levofloxacin (5µg), Erythromycin (5µg), Penicillin (10µg), Cefoxitin (30µg) and doxycycline (30µg), were aseptically applied to the agar surface. Thirty minutes after applying the discs, the plates were inverted and incubated at 37˚C. Cefoxitin-resistant *Staphylococci* isolates were phenotypically identified as Methicillin-resistant *Staphylococci*.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 25.0 (SPSS Inc., Chicago, IL, U.S.A.) software was utilized for statistical analysis. Chi-square analysis was employed to compare the distribution of methicillin-resistant *Staphylococci* (MRS) isolates among different states in northwestern Nigeria and other socio-demographic factors, including age, gender, occupation, educational qualifications, and economic status of the participants. A p-value of 0.05 was considered statistically significant at a 95% confidence level. Pearson's correlation was used to assess the relationship between the occurrence of MRS in wounds and nasal swabs. Logistic Regression Analysis was carried out to examine the influence of multiple independent variables (e.g., age, gender, educational status) on the likelihood of Methicillin resistance. Pearson's Product Moment Correlation (PPMC) was carried out to explore potential relationships between antibiotic susceptibility patterns and phenotypic characteristics of the *Staphylococci* isolates.

RESULTS

The Socio-demographic characteristics, which comprise age, gender, occupation, educational qualifications, and economic status of patients in relation to the distribution of methicillin-resistant *Staphylococci* from wounds and nasal swabs in some northwestern states in Nigeria, are shown in Table 1.0 and 2.0. The age group of patients sampled ranges from less than 1 to 80 years old. An age interval of 20 was chosen for each of the age groups. Methicillin-resistant *Staphylococcus aureus* (MRSA) isolates were highest at 72 (17.2%) among patients of 11-30 years, followed by 42 (10.0%) from 31-50 years, followed by 21 (5.0%) then 8 (1.9%)) isolates from ages 51-70 years, and the least was 09 (2.1%) from <1-10 years old. The high (16.7%) of Methicillin Susceptible *Staphylococcus aureus* (MSSA) isolates were obtained from patients whose ages range 11-30 years, followed by 33 (7.9%) MSSA from 31-50 years, then 10 (2.4%) from 51-70years, 8 (1.9%) and the least 3 (9.3%) isolates from 71-90 years old patients. For Methicillin-resistant Coagulase negative *Staphylococci* (MRCONS) isolates, the highest, 39 (9.3%) isolates were from 11-30 years old, followed by 31 (7.4%) from 31-50 years, then 11 (2.6%) from 51-70 years old, 7 (1.7%) from ages <1-10 years and the least was 1 (0.2%) from 71-90 years old. The most frequent 26 (6.2%) isolates of Methicillin susceptible Coagulase negative *Staphylococci* (MSCONS) isolates were from 11-30 years old, followed by 23 (5.5%) from 31-50 years, 6 (1.4%) from 51-70 years, 5 (1.2%) from <1-10 years and the least 1 (0.2%) from patients of ages 71-90 years old patients. No statistically significant difference in the distribution of MRS among the various age groups.

The gender distribution of methicillin-resistant *Staphylococci* from wounds and nasal swabs in some northwestern states of Nigeria is also displayed in Table 1.0. The distribution of *Staphylococci* isolates among male and female patients is seen in the table. Ninety (90) (21.5%) and 54 (12.9%) MRSA; 67 (16.7%) and 57 (13.6%) MSSA; 65 (15.5%) and 24 (5.7%) MRCONS; and 41 (9.8%) and 20 (4.8%) MSCONS were obtained from male and female specimen cultures respectively. No significant difference in the distribution of MRS among male and female patients.

With regards to the occupational distribution of *Staphylococci* isolates, out of 82 (10.2%) wounds and nasal swabs collected from civil servants, 55 (13.1%) *Staphylococci* isolates were identified, consisting of 21 (5.0%) MRSA, 16 (3.8%) MSSA, 15 (3.6%) MRCONS, and 3 (0.7%) MSCONS. Next are the business people, where out of 222 (27.5%) samples obtained from patients belonging to the business occupation, a total of 112 (26.8%) *Staphylococci* isolates were identified as 33 (7.9%) MRSA, 31 (7.4%) MSSA, 25 (6.0%) MRCONS, and 23 (5.5%) MSCONS. For students, 190 (23.6%) specimens yielded a total of 84 (20.1%) *Staphylococci* isolates comprising 32 (7.6%) MRSA, 24 (5.7%) MSSA, 13 (3.1%) MRCONS, and 15 (3.6%) MSCONS. One hundred and two (102) (12.6%) samples were collected from patients who are farmers by occupation, of which cultures yielded a total of 55 (13.1%) *Staphylococci* isolates, identified as 19 (4.5%) MRSA, 15 (3.6%) MSSA, 17 (4.1%) MRCONS, and 4 (0.9%) MSCONS isolates. The unemployed patients were the last group in the table, with 208 (29.8%) specimens collected from 104 unemployed patients, resulting in a total of 112 (26.7%) *Staphylococci* isolates, including 39 (9.3%) MRSA, 38 (9.1%) MSSA, 19 (4.5%) MRCONS, and 16 (3.8%) MSCONS. There is no significant difference in the distribution of MRS among patients.

The distribution of methicillin-resistant *Staphylococci* in wounds and nasal swab cultures based on patient's educational qualifications in some states of northwestern Nigeria is seen in Table 2.0. The distribution of *Staphylococci* isolates among patients based on various educational qualifications is as follows: Out of 144 (34.4%) MRSA culture isolates, 39 (9.3%) were from PSLC holders, 35 (8.4%) are from SSCE holders, 12 (2.9%) are from ND/NCE holders, 13 (3.1%) are from HND/Bachelor's Degree holders, 02 (0.5%) from HND/Bachelor's Degree holders, 02 (0.5%) from MSc. /PhD holders, 13 (3.1%) from Arabic education holders, and 30 (7.2%) from uneducated patients.

Of the 124 (29.7%) MSSA isolates, 17 (4.1%) belonged to PSLC holders, 33 (7.9%) to SSCE holders, 19 (4.5%) to ND/NCE holders, 13 (3.1%) to HND/First-degree holders, 2 (0.5%) to M.Sc. PhD holders, 5 (1.2%) to Arabic education holders, and 35 (8.4%) to undereducated patients. Among the 89 (21.3%) MRCONS isolates, 17 (4.1%), 25 (6.0%), 12 (2.9%), 3 (0.7%), 23 (5.5%), and 9 (2.1%) belonged to PSLC holders, SSCE holders, ND/NCE holders, HND/First-degree holders, Arabic education holders, and uneducated patients, respectively. The distribution of the 61 (14.6%) MSCONS isolates is as follows: 18 (4.3%), 12 (2.9%), 8 (1.9%), 9 (2.1%), and 14 (3.3%) among PSLC holders, SSCE holders, NCE holders, Arabic education holders, and uneducated patients, respectively. There is a statistically significant difference in the distribution of MRS among patients based on educational level.

The economic statuses of patients were assessed and recorded in the questionnaires, using gross monthly income as an indicator. The distribution of methicillin-resistant Staphylococci in wounds and nasal swabs based on patients' economic statuses was presented in Table 2.0. MRSA isolates were highest at 56 (13.3%) from patients with less than 25,000 naira monthly income, followed by 40 (9.6%) each from patients with no monthly income and those with an income range of 25,000-50,000 naira, then 7 (1.7%) from patients with an income range of 51,000-75,000 naira, and the least 1 (3.1%) MRSA isolate was from patients with a monthly income greater than 75,000 naira. The distribution of MRCONS followed a similar pattern, with the highest 26 (6.2%) of MRCONS isolates obtained from patients with no source of income, followed by 25 (6%) each from patients with less than 25,000 naira monthly income and those with an income range of 25,000-50,000 naira. The next was 10 (2.4%) from patients with 51,000-75,000 naira, while the least 3 (0.7%) MRCONS isolates were obtained from patients with a monthly income greater than 75,000 naira. There is no statistically significant difference in the distribution of MRS among patients based on their economic statuses.

Of a total of eight hundred and six (806) samples of wounds and nasal swabs collected and cultured from 403 patients in some states of northwestern Nigeria, only 652 (80.9%) were culture-positive, while 154 (19.1%) yielded no growth. Fifty-two (52) (6.45%) cultures yielded mixed growth. A total of 704 (87.3%) isolates were obtained from the primary isolation carried out on the samples. Out of these isolates, 418 (59.4%) were identified as *Staphylococci* isolates, including 144 (17.7%) Methicillin-Resistant *Staphylococcus aureus* (MRSA), 124 (15.4%) Methicillin-susceptible *Staphylococcus aureus* (MSSA), 89 (11%) Methicillin-Resistant Coagulase-negative *Staphylococci* (MRCONS), and 61 (7.6%) Methicillin susceptible Coagulase-negative *Staphylococci* (MSCONS) (Table 3.0). A chi-square (X^2) statistical analysis was conducted to compare the distribution of Methicillin-Resistant *Staphylococci* (MRS) in the study locations in selected states of northwestern Nigeria. The calculated result was 10.92, greater than the X^2 table value (3.841) at a degree of freedom = 1, P = 0.05.

Therefore, the null hypothesis is rejected, indicating a statistically significant difference in the distribution of MRS in some states of northwestern Nigeria. Data was also analyzed using Pearson's Correlation (r) to examine the level of association in the occurrence of MRS in wounds and nasal swabs. The result showed r = 1, indicating a strong positive relationship between the occurrence of MRS in wounds and nasal swabs of the patients sampled from some states of northwestern Nigeria.

Antibiotic susceptibility profiles of *Staphylococci* isolates from wounds and nasal swabs in some states of northwestern Nigeria were conducted, as shown in Table 4.0. Out of the 418 *Staphylococci* isolates analyzed, 164 (39.2%) were sensitive to Erythromycin (15µg), 28 (6.7%) showed intermediate sensitivity, and 266 (54.1%) were resistant. One hundred and ninety-six (46.9%) of the isolates were sensitive to Clindamycin (2µg), 42 (10%) showed intermediate sensitivity, and 180 (43.1%) were resistant. Regarding Cefoxitin (30µg), 185 (44.3%) isolates were sensitive, while 233 (55.7%) were resistant. Four hundred and eight(97.6%) isolates were sensitive to Vancomycin (30µg), 3 (0.7%) showed intermediate sensitivity, and 7 (1.7%) were resistant. Additionally, 230 (55%) isolates were sensitive to Doxycycline (30µg), 16 (3.8%) showed intermediate sensitivity, and 172 (41.1%) were resistant. With penicillin (10µg), 24 (5.7%) isolates were sensitive, 1 (0.2%) showed intermediate sensitivity, and 393 (94%) were resistant. A total of 204 (48.8%) staphylococcal isolates were sensitive to gentamycin (10µg), 33 (7.9%) showed intermediate sensitivity, and 181 (43.3%) were resistant. Twenty-six (6.2%) *Staphylococci* isolates were sensitive to Oxacillin (5µg), 7 (1.7%) showed intermediate sensitivity, and 385 (92.1%) were resistant. Lastly, for Levofloxacin (5µg), 170 (40.7%) isolates were sensitive, while 208 (49.8%) were resistant. Logistic Regression Analysis was carried out to examine the influence of multiple independent variables (e.g., age, gender, educational status) on the likelihood of Methicillin resistance. The analysis revealed that the Patient's Age, occupation, educational qualifications, and location significantly influence methicillin resistance, while their gender does not. Pearson's Product Moment Correlation (PPMC), carried out to explore potential relationships between antibiotic susceptibility patterns and phenotypic characteristics of the *Staphylococci* isolates, revealed statistically significant correlations between the type of bacteria and susceptibility to various antibiotics. However, the strength of these correlations varies. Erythromycin, Cefoxitin, and Levofloxacin exhibit moderate positive correlations, indicating a clearer association between *Staphylococci* isolates and susceptibility to these antibiotics. Clindamycin, Vancomycin, Penicillin, Gentamycin, and Oxacillin show weak positive correlations, suggesting a less clear but still present link between *Staphylococci* isolates and their susceptibility. Doxycycline displays a very weak positive correlation, implying a minimal association with *Staphylococci* isolates.

Table 1: The distribution of methicillin resistance *Staphylococci* isolates from Wounds and Nasal swabs in some northwestern states, Nigeria, based on the socio-demographic characteristics.

Socio-demographic Characteristics	No. of Patients (%)	No. of Specimen (%)	MRSA (%)	MSSA (%)	MRCONS (%)	MSCONS (%)	Total (%)	Chi-square (X^2)	p-Value
Age (years)									
<1-10	35 (8.7)	70 (8.7)	09 (2.1)	08 (1.9)	07 (1.7)	05 (1.2)	29 (6.9)	2.55	0.05
11-30	213(52.9m)	426(52.9)	72(17.2)	70(16.7)	39(9.3)	26(6.2)	207(49.5)		
31-50	100(24.8)	200(24.8)	42(10.0)	33(7.9)	31(7.4)	23(5.5)	129(30.9)		
51-70	52(12.8)	104(12.8)	21(5.0)	10(2.4)	11(2.6)	06(1.4)	48(11.5)		
71-90	03(0.7)	06(0.7)	0(0)	03(0.7)	1(0.2)	1(0.2)	5(1.2)		
Gender									
Male	270(67)	540(67)	90(21.5)	67(16.0)	65(15.5)	41(9.8)	263(62.9)	2.75	0.05
Female	133(33)	266(33)	54(12.9)	57(13.6)	24(5.7)	20(4.8)	155(37.1)		
Occupation									
C/servant	41(10.3)	82(10.3)	21(5.0)	16(3.8)	15(3.6)	3(0.7)	55(13.1)	4.36	0.05
Business	111(27.4)	222(27.4)	33(7.9)	31(7.4)	25(6.0)	23(5.5)	112(26.8)		
Students	95(23.6)	190(27.4)	32(7.6)	24(5.7)	13(3.1)	15(3.6)	84(16.7)		
Farming	52(12.8)	104(12.8)	19(4.5)	15(3.6)	17(4.1)	4(0.9)	55(13.1)		
Unemployed	104(25.9)	208(25.9)	39(9.3)	38(9.0)	19(4.5)	16(3.8)	112(100)		

Keys: MRSA = Methicillin Resistance *Staphylococcus aureus*; MSSA = Methicillin Susceptible *Staphylococcus aureus*; MRCONS = Methicillin Resistant Coagulase negative *Staphylococci*; MSCONS = Methicillin Susceptible Coagulase negative *Staphylococci*

Table 2: The distribution of methicillin resistance *Staphylococci* isolates from Wounds and Nasal swabs in some northwestern states of Nigeria, based on Educational qualifications and Economic status.

Socio-demographic Characteristics	No. of Patients (%)	No. of Specimen (%)	MRSA (%)	MSSA (%)	MRCONS (%)	MSCONS (%)	Total (%)	X^2	p-Value
Educational qualification									
PSLC	89(22.1)	178(22.1)	39(9.3)	17(4.1)	17(4.1)	18(4.3)	91(21.8)	20.67	0.05
SSCE	94(23.3)	188(23.3)	35(8.4)	33(7.9)	25(6.0)	12(2.9)	105(25.1)		
ND/NCE	54(13.4)	108(13.4)	12(2.9)	19(4.5)	12(2.9)	8(1.9)	51(12.2)		
BSc. /HND	31(7.7)	62(7.7)	13(3.1)	13(3.1)	3(0.7)	0(0)	29(6.9)		
MSc./PhD	01(0.2)	02(0.2)	02(0.5)	02(0.5)	0(0)	0(0)	04(0.9)		
Arabic	58(14.4)	116(14.4)	13(3.1)	5(1.2)	23(5.5)	9(2.1)	50(12.0)		
None	76(18.8)	152(18.8)	30(7.2)	35(8.4)	9(2.1)	14(3.3)	88(21.0)		
Economic Status									
<N25,000	140(34.7)	280(34.7)	56(13.3)	40(9.6)	25(6.0)	21(5.0)	142(34)	7.33	0.05
N25,000-N50,000	100(24.8)	200(24.8)	40(9.6)	24(5.7)	26(6.0)	13(3.1)	102(22.4)		
N51,000-N75,000	27(6.6)	54(6.6)	07(1.7)	18(4.3)	10(2.4)	03(0.7)	38(9.1)		
>N75,000	12(3.1)	24(3.1)	01(0.2)	09(2.1)	03(0.7)	02(0.5)	15(3.6)		
None	124(30.6)	248(30.6)	40(9.6)	33(7.9)	26(6.2)	22(5.3)	121(28.9)		

Table 3.0: Distribution of *Staphylococci* isolates from Wounds and Nasal Swabs in Some States of Northwestern Nigeria

	Name of States						
Name of State	Kano (%)	Katsina (%)	Jigawa (%)	Kaduna (%)	Total	X^2	p-Value
No. of Patients	150 (37.2)	90 (22.3)	70 (17.4)	93 (23.1)	403 (100)	11.0	0.05
No. of Specimen	300 (37.2)	180 (22.3)	140 (17.4)	186 (23.1)	806 (100)		
No. of MRSA	67 (16.0)	16 (3.8)	24 (5.7)	37 (8.8)	144 (34.4)		
No. of MSSA	25 (6.0)	23 (5.5)	31 (7.4)	45 (10.8)	124 (29.7)		
No. of MRCONS	54 (12.9)	15 (3.4)	11 (2.6)	9 (2.1)	89 (21.3)		
No. of MSCONS	22 (5.3)	18 (4.3)	16 (3.8)	5 (1.2)	61 (14.6)		
Grand Total	**168 (40.2)**	**72 (17.2)**	**82 (19.6)**	**96 (23.0)**	**418 (100)**		

Table 4: Antibiotic Susceptibility Profile of *Staphylococci* isolates from Wounds and Nasal Swabs in Some States of Northwestern Nigeria

Antibiotic Profile	Disc Conc. (µg)	Sensitive No. (%)	Intermediate No. (%)	Resistant No. (%)
Erythromycin (E)	15	164 (39.2)	28 (6.7)	226 (54.1)
Clindamycin (DA)	2	196 (46.9)	42 (10.0)	180 (43.1)
Cefoxitin (FOX)	30	185 (44.3)	0 (0)	233 (55.7)
Vancomycin (VA)	30	408(97.6)	3 (0.7)	7 (1.7)
Doxycycline (Do)	30	230 (55.0)	16 (3.8)	172 (41.1)
Penicillin (P)	10	24 (5.7)	1(0.2)	393 (94.0)
Gentamycin (GN)	10	204 (48.8)	33 (7.9)	181 (43.3)
Oxacillin (OX)	5	26 (6.2)	7(1.7)	385 (92.1)
Levofloxacin (LEV)	5	170 (40.7)	40 (9.6)	208 (49.8)

DISCUSSION

Despite intensive efforts to control resistant organisms by aggressive infection control and prevention methods, antibiotic-resistant *Staphylococci*, especially MRSA, has become the most common Hospital-acquired infection worldwide (Akerele *et al.*, 2015). *Staphylococcus aureus* is a well-known pathogen with an alarming increasing level of developing resistance to many available antimicrobial agents. The prevalence of Methicillin-resistant *Staphylococci* has increased in many parts of the world, particularly in northwestern Nigeria, causing serious infections in hospitals that pose a serious burden in terms of medical and socioeconomic costs and cause significant morbidity and mortality (El-Amin and Faidah, 2012). The research conducted among critically ill patients in some states of northwestern Nigeria's health Institutions goes a long way in having great impacts on patient care, infection control, and the need to establish antimicrobial stewardship in the facilities.

The prevalence of *Staphylococci* in wounds and nasal swabs in this study is high (59.4%). The prevalence is higher than 52.4% by Gali *et al.* (2013) from Kaduna state but lower than 61% in a study by Ibrahim *et al.* (2019) on the prevalence of *Staphylococcus* species from clinical samples in some hospitals in the Kano metropolis, Nigeria. Likewise, the prevalence of *Staphylococcus aureus* was also high (64.1%). The high prevalence of *S. aureus* in this research is consistent with the prevalence of 63.1% obtained by Garroy *et al.* (2019) in Asmara, Eritrea, East Africa, but higher than 44.5% by Aminu *et al.* (2017) from Aminu Kano Teaching Hospital (AKTH), Kano Nigeria, 49.5% by Akerele *et al.* (2015) from a study carried out in Benin city, and 33.3% by Ibrahim *et al.* (2019) from Kano, Nigeria.

The prevalence of Methicillin Resistance *Staphylococcus aureus* (MRSA) in this study was also high (34.4%.). It is higher than the 13.1% prevalence by Akanbi *et al.* (2012) at the University of Abuja Teaching Hospital 8% by Okon *et al.* (2014) in Northern Nigeria but lesser than the 48.5% prevalence by Aminu *et al.* (2017) at AKTH, Kano, 46.7% by Umar *et al.* (2023) at Sokoto, Nigeria, 48% by Soe *et al.* (2021) at Myanmar, South-east Asia and 40.7% by Iliya *et al.* (2020) from Kiambu County, Kenya. The prevalence of MRSA in developed and developing countries varies. A recent study highlighted that the prevalence of non-invasive MRSA in Germany has declined (Stryjeroski & Corey, 2014). Evidence showed that the prevalence of MRSA blood stream infection in the United States and Europe has declined recently (CDDE, 2015). Similarly, MRSA infection in Asia is trimming down (Lai *et al.*, 2014). In contrast, the prevalence of MRSA in African countries is not consistent, although the prevalence rate is still below 50%. Change in the trajectory of MRSA infection in developed countries is attributed to implementing control interventions (Lai *et al.*, 2014; Stryjewski and Corey, 2014). Surveillance of antibiotic resistance is a prerequisite to designing and implementing effective interventions. Unfortunately, Nigeria has no established surveillance system to date. Lack of these interventions, poor infection control, and inappropriate use of antibiotics could explain the rising trend (Abubakar and Sulaiman, 2018). In this study, the prevalence of MRSA in Kaduna state was low (8.85%). It is higher than 4.8% by Gali *et al.* (2013) and 7.8% by Umaru *et al.* (2019). In Kano State, the prevalence of *S. aureus* and MRSA were found to be 22% and 16%, respectively.

The prevalence in this study is lower than 36.7% and 21.1%, respectively, by Sanda *et al.* (2021) from Kano, 44.5% *S. aureus* and 44.8% MRSA by Aminu *et al.* (2017) and 28.6% MRSA by Nwankwo *et al.* (2010) from Kano, Nigeria.

The Prevalence of *S. aureus* and MRSA in Jigawa State from this study was 13.1% and 5.7%, respectively. This prevalence is lower than 40.6% *S. aureus* and 30.3% MRSA obtained by Hassan *et al.* (2021) in a research titled Prevalence and susceptibility pattern of *Staphylococcus aureus* in locally pasteurized cow milk sold at Dutse metropolis, Jigawa State, Nigeria. There is a paucity of data on recent studies related to *Staphylococci* in clinical samples from Jigawa State. The Prevalence of *S. aureus* and MRSA in Katsina State from this study was 17.2%, 9.3%, and 3.8%, respectively. There is a statistically significant association in the distribution of MRS in some states of northwestern Nigeria sampled for this study.

The prevalence of *Staphylococci* isolates in nasal swabs was 57%. Of 57% of *Staphylococci* isolates in nasal swabs, 54.7% are *Staphylococcus aureus*, while 45.2% are coagulase-negative *Staphylococci*. The 57% *Staphylococcus aureus* prevalence in nasal swabs from this research is higher than 49.5% by Akerele *et al.* (2015) in Benin City, 13.1% by Garroy *et al.* (2019) from a study in Asmara, Eritrea, 42.3% by Ogefere *et al.* (2020) from Benin City, and 36.1% by Sanda *et al.* (2021) from Kano metropolis, Northwest, Nigeria, but lower than 61.8% by Adeiza *et al.* (2020) from Sokoto state, Nigeria. The prevalence of 21% of MRSA Nasal swabs in this research is consistent with 22.2% by Akerele *et al.* (2015) from Benin City and 21.1% by Sanda *et al.* (2021) from Kano, Nigeria but lower than 37.2% by Ogefere *et al.* (2020) from Benin City and higher than 0.3% by Garroy *et al.* (2019) from Asmara, Eritrea.

Wound infections due to *S. aureus* and MRSA are a major concern in resource-limited countries, particularly Nigeria, where proper infection and control are still in place. The prevalence of *Staphylococci* in wound swabs is high (45%). Of the *Staphylococci* isolates, 75.5% were identified as *S. aureus*, of which 40.4% are MSSA, while 35.1% are MRSA; 24.5% are CONS, of which 14.4% were identified as MRCONS. The 45% prevalence of *Staphylococci* species isolates in wounds from this research is lower than 64.80% by Almeida *et al.* (2014) from hospitalized patients in inland northeastern Brazil but higher than 34.58% by Tsige *et al.* (2020) from Referral Hospital, northeast Ethiopia. The 75.5% prevalence of *S. aureus* in wounds from this study is consistent with 77.6% by Kumurya *et al.* (2017) from Kano, Nigeria, but higher than 33.3% by Ibrahim *et al.* (2019) from Kano and 38.7% by Sampson *et al.* (2022) from the University of Port-Harcourt Teaching Hospital, Rivers state, Nigeria. Also, the 35.1% prevalence of MRSA in Wounds from this study is lower than the 75% prevalence by Udobi *et al.* (2013) from ABUTH, Zaria, Kaduna state, Nigeria but higher than 32% by Almeida *et al.* (2014) Brazil and 28.3% by Tsige *et al.* (2020) from northeast Ethiopia. There is a statistically strong positive correlation in the distribution of MRS in wounds and nasal swabs. A similar research carried out in Denmark revealed that patients with nasal carriage of *S. aureus* and MRSA have the same colonies in their chronic ulcers, thereby showing that nasal colonization is a source of wound contamination in the same patient, as well as cross-contamination among patients (Gjodsbol *et al.*, 2013).

Antibiotic susceptibility test results from this research revealed that the most effective drug against MRS is Vancomycin (97.6%), while the least effective is penicillin (5.7%). The outcome of this study is in agreement with 100% by Iroha *et al.* (2012) from Abakaliki, Ebonyi state, Nigeria. In this research, resistance to penicillin, Oxacillin, Cefoxitin, and Erythromycin were observed to be over 50%. This is likely due to the indiscriminate use of antibiotics and prescriptions by unqualified and unlicensed health personnel. As discovered from the questionnaires, 4.2% of respondents were in the habit of self- medications, 16.4% patronizes patent medicine shops, 12.1% consult with traditional healers, and 6.7% visit primary health care centers whenever they need medical attention. Only 44% of respondents claimed to visit secondary and tertiary health care centers. Also, 15.6% of respondents don't complete their medications even if they received appropriate prescriptions from authorized health personnel. In the present study, the proportion of resistance to multiple antibiotics is high, which may be attributed to the previous usage of antibiotics by a majority (74%) of the patients. The occurrence frequency of MRS was highest among patients belonging to age group 11-30 years old, male patients presented a higher isolation rate than female patients. The occurrence of MRS was low among patients with a high level of formal education but higher among those with a low level of education. MRS culture yield was higher among patients with little income earnings when compared to those having an appreciable monthly income. The prevalence of methicillin-resistant *Staphylococci* in wounds and nasal swabs in this study is fairly high (34.4%). Vancomycin and Doxycycline were the most effective antibiotics against Methicillin-resistant *Staphylococci*.

CONCLUSION

The prevalence of methicillin resistance *Staphylococci* in Wounds and nasal swabs in this study is fairly high. Most of the isolates were resistant to multiple antibiotics; resistance to penicillin, Oxacillin, Cefoxitin, and Erythromycin were over 50%. From the present research, the frequency of Methicillin-resistant *Staphylococci* isolation was higher in male than female patients. The age range of 11-30 years has the highest prevalence. Poverty, lack of awareness, indiscriminate use of antibiotics, and poor infection control measures were found to be responsible for the spread of MRS infections.

Competing Interest

Authors declare that no competing interest

REFERENCES

Abubakar, S. and Sulaiman, A. S. (2018): Prevalence, trend and antimicrobial susceptibility of Methicillin resistant *Staphylococcus aureus* in Nigeria. A systematic review, *Journal of Infection and Public Health*. 11 (2018): 763-770. [Crossref]

Adeiza, S. S., Onalapo, J. A. and Olayinka, B. O. (2020): Prevalence, risk factors and antimicrobial susceptibility profile of Methicillin resistant *Staphylococcus aureus* obtained from nares of Patients and staff of Sokoto state owned Hospitals in Nigeria. *G. M. S. Hygiene and Infection Control*, 2020, Vol. 15, ISSN 2196-5226. [Crossref]

Akanbi, B. O. and Mbe, J. U. (2012): Occurrence of Methicillin and Vancomycin resistant *Staphylococcus aureus* in University of Abuja Teaching Hospital, Abuja, Nigeria. *African Journal of Clinical Microbiology*, 2012, 14 (1): 1-4. [Crossref]

Akerele, J. O., Obasuyi, O. and and Omede, D. (2015): Prevalence of Methicillin resistant *Staphylococcus aureus* among healthy residents of Ekosodin Community in Benin City, Nigeria. *Tropical Journal of Pharmaceutical Research*. August 2015; 14 (8): 1495-1499. [Crossref]

Almeida, G. C. M., Santos, M. M., Cidral, T. A., Melo, M. C. N. and Lima, K. C. (2014): Prevalence and factors associated with wound colonization by *Staphylococcus* species and *S. aureus* in hospitalized Patients in Inland northeastern Brazil: A cross-sectional study. *B. M. C. Infectious Diseases* 2014, 14: 328. [Crossref]

Aminu, A. I., Abdullahi, S. and Usman, M. I. (2017): Detection of Methicillin Resistant *Staphylococcus aureus* (MRSA) from Hospital Instruments. *Umar Musa Yaradu'a University Journal of Microbiology Research*, Volume 2 No.1, June, 2017. Pp. 10-21. [Crossref]

Ayliffe, G. A. (1997): The progressive intercontinental spread of methicillin-resistant *Staphylococcus aureus*. *Clinical Infectious Diseases* 24 (Suppl 1):S74–S79. [Crossref]

Baker, F.J., Silverton, R.F. and Pallister, C.J. (2000): Staining of Smears: Gram's stain. Introduction to Medical Laboratory Technology (Seventh Edition), Bounty Press Limited, Nigeria.

Borg, M. A. and Camilleri, L. (2021): What is driving the Epidemiology of Methicillin resistant Staphylococcus aureus Infections in Europe? Microbiological Drug Resistance, 27: 889-994. [Crossref]

Center for Desease Dynamics, Economics and Policy (2015): State of the Worlds antibiotics. Washington DC: CDDEP; 2015, Pp. 1-3.

Cheesbrough, M. (2002): Biochemical Tests. District Laboratory Practice in Tropical Countries, Part 2. Cambridge University Press, United Kingdom: 135-142, 158-159.

Clinical and Laboratory Standards Institute (2016): Performance Standards for Antimicrobial Susceptibility Testing Approved Standard M100-S23. Clinical and Laboratory Standards Institute, Wayne, PA.

Cockerill, F. (2012): Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria that Grow Aerobically; Approved Standard, 9th Edition, Clinical Laboratory Standard Institute. Pp 12.

Dangari, M. A., Sunusi, A. A., Salihu, K. M. and Ado, A. (2024): Phenotypic and Molecular Detection of MRSA isolated from clinical samples in some selected Hospitals in Dutsin-Ma and Kurfi Local Government Area, Katsina State. Arid Zone Journal of Basic and Applied Research. Volume 3 (3): 133-144.

Duran, N., Ozer, B., Duran, G. G., Onlen, Y., and Demir, C. (2012): Antibiotic Resistance Genes & AMP; Susceptibility Patterns in *Staphylococci*. Indian. *Journal of Medical Research* 2012; 135: 389-96.

El-Amin, N.M. and Faidah, H. S. (2012): Methicillin-resistant *Staphylococcus aureus* in the western region of Saudi Arabia: Prevalence and antibiotic susceptibility pattern. *Annual Saudi Medicine*, 32: 513-516. [Crossref]

European Center for Disease Control (2019): Antimicrobial resistance. Annual Epidemiological report 2019. *https//www.ecdc.europa.eu/en/publication.data/surveillance-antimicrobial-resistance-europe-2019*.Camilleri, L. (2020): What is driving the Epidemiology of Methicillin resistant *Staphylococcus aureus* Infections in Europe? *Microbiological Drug Resistance* 2020, 27: 889-994.

Gali, A. U., Junaid, K., Umoh, V. J. and Kwaga, J. K. P. (2013): Methicillin resistant *Staphylococcus aureus* in Fresh and fermented Milk in Zaria and kaduna, Nigeria. *International Journal of Drug and Research Technology*. 2013, Volume 3 (3): 65-67.

Garoy, E. Y., Gebreab, Y. B., Achila, D. G. T., Keset, R., Ghirmay, R. and Yesfu, T. (2019): Methicillin resistant *Staphylococcus aureus* Prevalence and antimicrobial sensitivity pattern among Patients – A multicenter study in Asmara, Eritrea. *Canadian Journal of Infectious Diseases and medical Microbiology*. Vol. 2019, Article I.D 8321834, Pp. 1-9. **[Crossref]**

Ghanbari, F., Saberianpour, S., Zarkesh-Eshfahani, F., Ghambari, N., Taraghian, A. (2017): Staphylococcal Cassette Chromosome mec (SCCmec) Typing of Methicillin-Resistance *Staphylococcus aureus* Strains isolated from Community and Hospital-acquired Infections. *Avecenna Journal of Microbial Infections*, 2017; **4** (2): 42244. **[Crossref]**

Gjodsbol, K.,Skindersac, M. E., Skov, R. L. and Krogfelt, K. A. (2013): Cross-contamination: comparison of nasal and chronic leg ulcer *S. aureus* strains isolated from same Patient. *Open Microbiology Journal*, 2013, 7: 6-8. **[Crossref]**

Gurusamy, K., Selvan, K., Clare, D., Wilson, P. and Brian, R. (2013): Antibiotic Therapy for the Treatment of Methicillin-resistant *Staphylococcus aureus* (MRSA) Infections in Surgical Wounds. *The Cochrane Database of Systematic Reviews* (8): Pp. 7-9. **[Crossref]**

Han, J. H., Edelstein, P. H., and Lautenbach, E. (2012): Reduced Vancomycin Susceptibility and Staphylococcal Cassette Chromosome mec (SCCmec) type distribution in methicillin-resistant *Staphylococcus aureus* bacteremia. *Jounal of Antimicrobial Chemother*apy 2012; : 1-4. **[Crossref]**

Hassan, R. S., Aliyu, S. H., Adam, S. A., Mender, B. S. ans Muhammad, A. S. (2021): Prevalence and susceptibility patterns of *Staphylococcus aureus* in locally Pasteurized Cow-milk sold at Dutse metropolis, Jigawa state, Nigeria. *International Journal of Biology Sciences*. Volume 3, Issue 1, 2021, Pp. 25-29. **[Crossref]**

Ibrahim, S. M., Faruk, S. N., Kabiru, A G. and Muhammad, A. (2019): Prevalence of *Staphylococcus* species from Clinical samples obtained from some Hospitals in Kano Metropolis, Nigeria. *American Journal of Biomedical Science and research*. 2019, 5 (3): 207-210. **[Crossref]**

Iliya, S. Mwagi, J., Maathai, R. and Muriuki, M. (2020): Phenotypic analysis and Antibiotic susceptibility of Methicillin resistant *Staphylococcus aureus* in Kiambu County, Kenya. *The Journal of Infection in Developing Countries*, 2020; 14 (6): 597-605. **[Crossref]**

Iroha, I. R., Nwakaeze, E. A., Oji, E. A., Nwosu, K. O. and Ayogu, A. E. (2012): Prevalence of Methicillin resistant *Staphylococcus aureus* from Nasal Swabs of hospitalized Children in Abakaliki. *Nigerian Journal of Biotechnology*, Vol. 24 (2012): 1-6.

Jevons, M. P. 1961. "Celbenin"-resistant *staphylococci*. *Br. Medical Journal*. 1:124-125. **[Crossref]**

Kumurya, A. S. (2015): Detection of *Staphylococcus aureus*-Specific Gene and Simultaneous Confirmation of methicillin Resistant *Staphylococcus aureus* (MRSA) by Polymerase Chain Reaction. *Clinical Medicine Journal, American Institute of Science*, Volume **1**, No. 3. http://www.aiscience.org/journal/cmj.

Kumurya, A. S., Sule, H. and Maje, A. U. (2017): *Staphylococcus aureus* from microbial load of open wounds from Patients attending Aminu Kano Teaching Hospital, Kano, Nigeria. *Journal of Bacteriology and Mycology*, Volume 5 (7): 434-437. **[Crossref]**

Lai, C. C., Lee, K., Xiao, Y., Ahmad, N., Veeraghavan, B. and Thaulikikul, V. (2014): High burden of Antimicrobial Drug resistance in Asia. Journal of Global Antimicrobial Resistance 2014: 2 (3) 141-147. **[Crossref]**

Ma, X. X., Ito, T., Tiensasitorn, C., Jamklang, M., Chongtrakool, P., Boyle-Vavra, S., Daum, R. S. and Hiramatsu, K. (2002): Novel type of staphylococcal cassette chromosome *mec* identified in community-acquired methicillin-resistant *Staphylococcus aureus* strains. *Antimicrobial Agents Chemotherapy* **46**:1147–1152. **[Crossref]**

McFarland, J. (1907): Nephelometer: An Instrument used for estimating the number of Bacteria in Suspensions and calculation of Opsonic Index, including Vaccines. *Medical Association*. 14: 1176-1178. **[Crossref]**

Naing, T., Winn, B. N. and Rusli, R. (2006): Practical Issues in Calculating the Sample Size for Prevalence Studies. *Medical Statistics, Archives of Orofacial Sciences* 2006; **1**: 9-14.

Nas, F. S., Yahaya, A., Zage, A. U., Garba, K. A. and Ali, M. (2018): Characterization and Evaluation of Antibiotic Susceptibility Pattern of Clinical isolates of Methicillin-resistant *Staphylococcus aureus* at some Tertiary Hospitals in Kano, Nigeria. International Journal of Research Studies in Microbiology and Biotechnology, Volume **4**, Issue 3: 38-44. **[Crossref]**

Nwankwo, E. O. K., Sale, A., Magaji, A. and Ihesiulor, G. (2010): Methicillin resistant *Staphylococcus aureus* and their antibiotic sensitivity pattern in Kano, Nigeria. *African Journal of Clinical and Experimental Microbiology*, January 2010, 11 (1): 129- 136. **[Crossref]**

Ochei, J. and Kolhatkar (2000): Laboratory Diagnosis of Staphylococcal Infections. Medical Laboratory Science Theory and Practice. Tata McGraw- Hill Publishing Company Limited, New Delhi.

Ogefere, H. O., Umaru, G., Ibadin, E. E. and Omoregie, R. (2019): Prevalence of Methicillin resistant *Staphylococci* among apparently healthy Students attending a tertiary Institution in Benin City, Nigeria. *Nigerian Journal of basic and applied Science* (June, 2019), 27 (1): 114-121. **[Crossref]**

Okon, K. O., Shittu, A. O. Kudi, A. A., Umar, H. nad Becker, K. (2014): Population Dynamics of *Staphylococcus aureus* in northeastern Nigeria in 2007 and 2012. *Epidemiology Infection Journal* 2014: 142 (8):1737-1740. **[Crossref]**

Sampson, T., Alexander, J. and Ugboma, C. J. (2022): Incidence of *Staphylococcus aureus* wound infection amongst Patients attending University of Port Harcourt Teaching Hospital, Rivers State, Nigeria. *Saudi Journal of Pathology and Microbiology*, 7 (7): 307-312. **[Crossref]**

Sanda, M. I., Kwaga, J. K. P., Suleiman, A. B. and Idris, A. M. (2021): Occurrence of Methicillin resistant *Staphylococcus aureus* among Horses and Horse handlers in Kano Metropolis, northwestern Nigeria. *Dutse Journal of Pure and Applied Sciences, DUJOPAS* Vol. 7, No.1, March, 2021 Pp. 280-287. **[Crossref]**

Schullman, J. S. (2023): All you need to know about Methicillin-resistant *Staphylococcus aureus*. *www.medicalnewstoday.com*

Soe, P. E., Han, W. W., Sagili, K. D., Satyanarayana, S., Shrestha, P. and Htoon, T. T. (2021): High prevalence of Methicillin-resistant *Staphylococcus aureus* among Health facilities and its related factors in Myanmar. *Journal of Tropical Medicine and infectious Diseases*, **6** (70): 1-13. **[Crossref]**

Stryjewski, M. E. and Corey, G. R. (2014): Methicillin resistance *Staphylococcus aureus*: an enveloping pathogen. *Clinical Infectious Disease* **58** (1): 9-10. **[Crossref]**

Stryjewski, M. E. and Corey, G. R. (2014): Methicillin resistance Staphylococcus aureus: an enveloping pathogen. Clinical Infectious Disease 58 (1): 9-10. **[Crossref]**

Sunusi, A. A., Dangari, M. A., Salihu, K. M. and Ado, A. (2023): Molecular Detection of mecA Gene in MRSA isolated from surfaces of public Hospitals in Katsina State, Nigeria. Umaru Musa Yar'adua University Journal of Microbiology Research, Volume 8 (2): 110-112. **[Crossref]**

Tankeshwar, T. (2022): Mannitol Salt Agar: Principle, uses and results. *www.microbeonline.com*

Tong, S. Y. C., Davis, J. S., Eichenberger, E., Holland, T. L., Fowler, V. G. (2015): *Staphylococcus aureus* infections: Epidemiology, Pathophysiology, clinical manifestations and management. *Clinical Microbiology Review* 2015, 28, 603-661. **[Crossref]**

Tsige, Y., Tadesse, S., Eyesus, T. G. and Gelaw, B. (2020): Prevalence of Methicillin Resistant *Staphylococcus aureus* and associated risk factors among Patients with Wound infection at Referral Hospital Ethiopia. *Journal of Pathology*, e3168325. Center for Desease Dynamics, Economics and Policy (2015): State of the Worlds antibiotics. Washington DC: *CDDEP*; 2015, Pp. 1-3. **[Crossref]**

Udobi, C. E., Obajuluwa, A. E. and Onaolapo, J. A. (2013): Prevalence and Antibiotic resistance pattern of Methicillin resistant *Staphylococcus aureus* from an Orthopaedic Hospital in Nigeria. Hindawi Publishing Corporation. *Biomedical Research International*, Vol. 13. Pp. 1-4. **[Crossref]**

Umar, A. I., Manga, S. B., Baki, A. S. and Uba, A. (2023): Molecular characterization and epidemiology of Methicillin resistant *Staphylococcus aureus* isolated from clinical Samples in Sokoto, Nigeria. *Adesh University Journal of Medical Sciences and Research*.. Pp1-8. **[Crossref]**

Umaru, G. A., Kwaga, J. K. P., Bello, M., Raji, M. A., maitala, Y. S. and Junaidu, K. (2019): Prevalence and Antibiotic susceptibility of Methicillin resistant *Staphylococcus aureus* isolated from Bovine mastitis in settled Fulani herds in Kaduna State. *Nigerian Veterinary Journal*, Vol. 40 (3):190-200. **[Crossref]**