



Short Communication

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Multidrug-resistant *Staphylococcus aureus* associated with neonatal sepsis in the special care baby unit of a secondary healthcare facility in Katsina State, Nigeria

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Abstract:

Background: Neonatal sepsis remains a major cause of morbidity and mortality in developing countries, with *Staphylococcus aureus* being one of the leading causative organisms. The rising occurrence of multidrug-resistant (MDR) strains poses significant therapeutic challenges. This study aimed to determine the antibiotic resistance pattern and multiple antibiotic resistance (MAR) index of *S. aureus* isolated from neonatal sepsis cases in the Special Care Baby Unit (SCBU) of a secondary healthcare facility in Katsina State, Nigeria.

Methodology: A hospital-based cross-sectional study was conducted involving 155 neonates with suspected sepsis. Blood samples were aseptically collected and cultured using standard microbiological techniques. *Staphylococcus aureus* isolates were identified through colony morphology, Gram staining, and biochemical tests. Antibiotic susceptibility test was performed using the Kirby-Bauer disk diffusion method in accordance with Clinical Laboratory Standards Institute (CLSI) guidelines. Multi-drug resistance was defined as resistance of an isolate to three or more classes of antibiotics. The MAR index for each isolate was calculated as the ratio of the number of antibiotics resisted to the total number tested.

Results: Of the blood samples analyzed for 155 clinical neonatal sepsis cases, 65 (41.9%) were culture-positive for bacterial pathogens, with 31 (20.0%) *S. aureus* isolates, which exhibited high resistance to erythromycin (87.0%), cefoxitin (83.0%), ampicillin (64.0%) and gentamicin (64.0%). Although resistance to imipenem was lowest at 51.0% among the antibiotics tested, this value still indicated a relatively high resistance rate. Overall, MDR was detected in 74.0% of the isolates, indicating high AMR burden among *S. aureus* associated with neonatal sepsis. Among the isolates, 83.9% were methicillin-resistant *S. aureus* (MRSA) while 64.5% were gentamicin-resistant *S. aureus* (GRSA). The MAR index of the *S. aureus* isolates ranged from 0.2 to 1.0, with a mean value of 0.7 ± 0.3 , but most isolates (93.5%) exhibited MAR index values higher than 0.2.

Conclusion: The high prevalence of MDR and high MAR index values among *S. aureus* isolates indicate significant antibiotic selection pressure within the SCBU of the facility studied. Strengthened antimicrobial stewardship and routine AMR surveillance are urgently required to improve neonatal sepsis outcomes.

Keywords: Neonatal sepsis, *Staphylococcus aureus*, Multiple antibiotic resistance index, Multidrug resistance, SCBU.

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***Staphylococcus aureus* multirésistant associé à une septicémie néonatale dans l'unité de soins intensifs néonataux d'un établissement de soins de santé secondaires de l'État de Katsina, au Nigéria**

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Résumé:

Contexte: La septicémie néonatale demeure une cause majeure de morbidité et de mortalité dans les pays en développement, *Staphylococcus aureus* étant l'un des principaux agents pathogènes. L'augmentation de la fréquence des souches multirésistantes (MDR) pose d'importants défis thérapeutiques. Cette étude visait à déterminer le profil de résistance aux antibiotiques et l'indice de multirésistance aux antibiotiques (MAR) de *S. aureus* isolé chez des nouveau-nés atteints de sepsis dans l'unité de soins intensifs néonataux (USIN) d'un établissement de soins de santé secondaires de l'État de Katsina, au Nigéria.

Méthodologie: Une étude transversale hospitalière a été menée auprès de 155 nouveau-nés présentant une suspicion de sepsis. Des échantillons de sang ont été prélevés de manière aseptique et mis en culture selon les techniques microbiologiques standard. Les isolats de *S. aureus* ont été identifiés par morphologie des colonies, coloration de Gram et tests biochimiques. L'antibiogramme a été réalisé par la méthode de diffusion sur disque de Kirby-Bauer, conformément aux recommandations d'Institut des Normes de Laboratoire Clinique (CLSI). La multirésistance a été définie comme la résistance d'un isolat à trois classes d'antibiotiques ou plus. L'indice MAR de chaque isolat a été calculé comme le rapport entre le nombre d'antibiotiques auxquels il est résistant et le nombre total d'antibiotiques testés.

Résultats: Sur 155 échantillons sanguins analysés pour des cas cliniques de sepsis néonatal, 65 (41,9 %) étaient positifs à la culture pour des agents pathogènes bactériens, dont 31 (20,0 %) isolats de *S. aureus*. Ces isolats présentaient une forte résistance à l'érythromycine (87,0%), à la céfoxitine (83,0%), à l'ampicilline (64,0%) et à la gentamicine (64,0%). Bien que la résistance à l'imipénem soit la plus faible (51,0%) parmi les antibiotiques testés, ce taux reste relativement élevé. Au total, une multirésistance a été détectée chez 74,0% des isolats, témoignant d'une forte prévalence de résistance aux antimicrobiens chez *S. aureus* associé au sepsis néonatal. Parmi les isolats, 83,9 % étaient des *S. aureus* résistants à la méthicilline (SARM) et 64,5 % des *S. aureus* résistants à la gentamicine (SARM). L'indice MAR des isolats de *S. aureus* variait de 0,2 à 1,0, avec une valeur moyenne de $0,7 \pm 0,3$. Cependant, la plupart des isolats (93,5%) présentaient des valeurs d'indice MAR supérieures à 0,2.

Conclusion: La forte prévalence de la multirésistance et les valeurs élevées de l'indice MAR parmi les isolats de *S. aureus* indiquent une pression de sélection antibiotique importante au sein de l'unité de soins intensifs néonataux (USIN) de l'établissement étudié. Un renforcement de la gestion des antimicrobiens et une surveillance systématique de la résistance aux antimicrobiens sont nécessaires de toute urgence pour améliorer la prise en charge de la septicémie néonatale.

Mots-clés: Septicémie néonatale, *Staphylococcus aureus*, Indice de résistance à de multiples antibiotiques, Multirésistance, USIN.

Introduction:

Worldwide, neonatal sepsis is a leading cause of morbidity and mortality, particularly in low- and middle-income countries with limited access to prompt diagnosis and effective antibiotic treatment (1). Bacterial infections continue to be the primary cause of sepsis in this age group, and neonates with sepsis do not normally present specific clinical signs and symptoms. This lack of specific clinical presentations makes early diagnosis and treatment difficult (2).

Staphylococcus aureus remains one of the most common bacterial pathogens associated with bloodstream infections in neonates (3). More than half of the culture-confirmed neonatal sepsis cases in a study in southwest Nigeria were caused by *S. aureus*, and the isolates had a high frequency of resistance to me-

thiillin (4). Similarly, *S. aureus* has been identified by regional surveillance studies as a major cause of neonatal infections, often associated with high levels of antibiotic resistance (5). This is because *S. aureus* has a remarkable ability to easily develop resistance by horizontal gene transfer, mutation of the chromosome, or selective pressure arising from excessive antibiotic usage (6). The growing prevalence of antibiotic-resistant bacteria in neonatal care settings poses a great threat to effective clinical management. The World Health Organization considers antibiotic resistance a global threat that causes approximately 700,000 deaths worldwide, rendering antibiotics ineffective against microorganisms (7).

The high rate of multidrug resistance (MDR) in *S. aureus* complicates empirical treatment protocols and is linked to higher mortality, longer hospital stays, and higher health-

care costs (8). (9) opined that antibiotic misuse and a lack of antimicrobial stewardship infrastructure in Nigeria and other sub-Saharan African countries contribute to the burden of antimicrobial resistance in bloodstream isolates, thereby helping resistant strains persist and spread further. Although several studies have reported antimicrobial resistance patterns of *S. aureus* in Nigeria, updated regional data, particularly in special care baby units (SCBUs) are lacking due to the high risk of antibiotic exposure.

Antibiotic resistance assessment at the isolate level is essential for directing empirical treatment and infection control measures (3). High multiple antibiotic resistance (MAR) indices indicate greater exposure to antibiotics, stronger selection pressure, and a higher risk of treatment failure. The MAR index is a numerical indicator that is determined for each isolate based on the number of antibiotics to which it is resistant relative to the total number of antibiotics tested (10). Organisms with a high MAR index rate exhibit unsuccessful antibiotic treatments and a high source of potentially dangerous drug-resistant bacteria making continuous monitoring necessary (7).

Despite its clinical significance, there is a paucity of data on MAR indices of *S. aureus* isolates from neonatal sepsis cases in Katsina, Nigeria. The study, therefore, aims to determine the pattern of antibiotic resistance and MAR indices of *S. aureus* in the SCBU of a secondary healthcare facility in Katsina State, and to assess the relationship between MRSA and MDR among the isolates, in order to better inform local antibiotic resistance policy and stewardship interventions.

Materials and method:

Study design and setting:

This study was a cross-sectional, hospital-based design carried out in the SCBU of Turai Yar'adua Maternity and Children Hospital, Katsina. The facility is located in Katsina metropolis, Katsina State, Nigeria, and is dedicated to offering specialized healthcare services to pregnant women, newborns, and children.

Ethical approval:

Ethical approval was obtained from the Katsina State Ministry of Health (MOH/ADM/SUB/1152/1/1160) based on the study compliance with ethical standards. Additionally, written informed consent was obtained from each

neonate's parents/guardians, anonymity, and confidentiality were maintained.

Study population and sample size:

The study considered neonates with clinical signs and symptoms suggestive of neonatal sepsis according to International Management of Neonatal and Childhood Illnesses (IMNCHI) (11). The sample size was determined using the single population proportion formula; $n = Z^2 p(1-p)/d^2$, and neonatal sepsis prevalence of 11.5% ($p=0.115$) reported in a previous study in Bangladesh (12) was used, with assumption of 5% error margin, a confidence interval 95%, and non-response rate of 5%. This gave a sample size of approximately 155 participants.

Selection criteria:

The inclusion criteria were neonates (0-28 days) admitted to the SCBU of the selected hospitals within the study period and symptomatic of neonatal sepsis according to the established clinical and haematological criteria of IMNCHI, any one or combinations of the symptoms and signs; poor feeding, convulsion, respiratory distress, hypothermia, hyperthermia, movement only when stimulated, and severe chest-in drawing (11), and whose parents granted permission for their neonates to participate in the study. Neonates admitted for non-infectious or surgical reasons, those with incomplete data, and those whose parents or legal guardians did not grant permission were excluded from the study.

Sampling technique:

The sampling technique for selection of participants was based on a similar study (13), which employs consecutive sampling technique. All neonates admitted to the SCBU who met the inclusion criteria were recruited consecutively as they presented during the study period.

Sample collection:

Blood specimens (2-3 ml) were collected aseptically by trained clinicians from neonates suspected of having sepsis prior to initiation of antimicrobial therapy, following standard clinical microbiology practices. Blood was immediately inoculated into conventional blood culture bottles. The needle was inserted through the rubber liner of the bottle cap, and the blood was dispensed into the culture medium bottle containing 10ml of Brain Heart Infusion (BHI) broth. Bottles were appropriately labeled with the patient's name and number, the date

and time of collection, and incubated aerobically at 37°C for 24 hours (2).

Isolation and identification of *S. aureus*:

Positive blood cultures were sub-cultured on Blood agar and Mannitol Salt Agar (MSA) and incubated at 37°C for 24 hours. Pure colonies showing morphological characteristics consistent with *S. aureus* (golden yellow colonies on MSA and β -hemolysis on blood agar) were selected for further identification. Gram staining was performed to confirm Gram-positive cocci in clusters. Biochemical tests, including catalase and coagulase, were used to differentiate *S. aureus* from other staphylococcal species, in accordance with standard microbiological identification protocols (14).

Antibiotic susceptibility testing (AST):

The Kirby-Bauer disc diffusion technique was used for antibiotic susceptibility testing (AST) by inoculating 0.5 McFarland standard suspension of overnight cultures of *S. aureus* onto the surface of a sterile Mueller-Hinton agar plate. Commercial antibiotic disks were placed on the agar plate with a sterile forcep. The disks used were ampicillin (10 μ g), cefoxitin (30 μ g), ciprofloxacin (5 μ g), imipenem (10 μ g), erythromycin (15 μ g), and gentamicin (10 μ g). Following a 24-hour incubation at 37°C, the zone of inhibition was measured to the nearest millimeter and interpreted as susceptible (S), intermediate (I), or resistant (R) based on CLSI guidelines (15).

MRSA isolates were phenotypically identified if the cefoxitin disk zone of inhibition was less than or equal to 21mm, while isolates with zone of inhibition equal to 22 mm or higher were considered methicillin-susceptible *S. aureus* (MSSA) (15). Gentamicin resistant *S. aureus* (GRSA) was identified as isolates showing gentamicin disk zones of inhibition less than or equal to 12 mm (15). Multidrug resistance (MDR) was reported as resistance of a *S. aureus* isolate to three or more classes of antibiotics tested against the isolate (16).

Multiple antibiotic resistance (MAR) index:

The AST results were used to calculate the MAR index. MAR index was calculated as the ratio of the number of antibiotics to which an organism is resistant to the total number of antibiotics tested for each *S. aureus* isolate. $MARI = a/b$, where 'a' is number of antibiotics the isolate is resistant to, and 'b' is total number of antibiotics tested. Isolate with MARI of ≥ 0.2 originates from a high-risk contamination source where several antibiotics are used.

Statistical analysis:

Data were analyzed using SPSS version 23.0. Descriptive statistics were used to summarize the data using averages, means, percentages, and standard deviations. Chi-square test was used to determine the relationship between MRSA and MDR. A *p*-value < 0.05 was considered statistically significant.

Results:

Distribution of *S. aureus* isolates in the study participants:

A total of 65 (41.9%) bacterial isolates were obtained from blood samples of 155 neonates with clinical suspicion of sepsis, of which 31 (20.0%) *S. aureus* isolates were identified biochemically as shown in Table 1.

Table 1: Prevalence of *Staphylococcus aureus* isolates from blood samples of neonates with neonatal sepsis

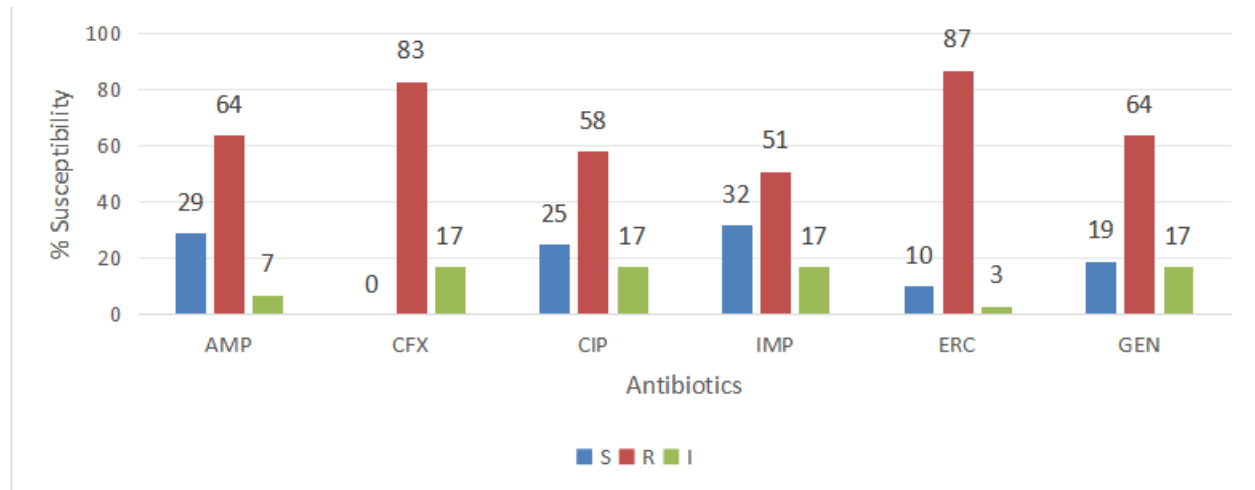
Participant blood samples	Number	Percentage
Negative cultures	90	59.1
Positive cultures	65	41.9
<i>Staphylococcus aureus</i>	31	20.0
Other pathogens	34	21.9

Antibiotic resistance of the *S. aureus* isolates:

Staphylococcus aureus isolates exhibited resistance to multiple classes of antibiotics (Fig 1). The highest rates of resistance were observed for erythromycin (87.0%) and ciprofloxacin (58.0%). Resistance was also high for ampicillin (64.0%) and gentamicin (64.0%). The highest susceptibility among the isolates was observed for imipenem (32.0%), although this value still reflects relatively low susceptibility overall. Approximately 50.0% of the isolates were resistant to more than half of the antibiotics tested.

Prevalence of methicillin, gentamicin and multidrug resistance among *S. aureus* isolates:

Table 2 shows the prevalence of methicillin gentamicin and multidrug resistance among the 31 *S. aureus* isolates. Of the isolates, 26 (83.9%) were identified as MRSA, while 5 (16.1%) were MSSA. Twenty isolates (64.5%) were resistant to gentamicin, while 11 (35.5%) were susceptible. Furthermore, 23 (74.0%) of the isolates were MDR, while 8 (26.0%) were non-MDR.



S= Sensitive; I= Intermediate; R= Resistance; AMP=Ampicillin CFX=Cefoxitin CIP=Ciprofloxacin IMP=Imipenem ERC=Erythromycin GEN=Gentamicin

Fig 1: Antibiotic susceptibility of *Staphylococcus aureus* isolates to selected antibiotics

Table 2: Prevalence of methicillin, gentamicin and multidrug resistance among *Staphylococcus aureus* isolates.

Isolate resistance characteristics		Frequency (n)	Percentage (%)
Methicillin	MRSA	26	83.9
	MSSA	5	16.1
Gentamicin	GRSA	20	64.5
	GSSA	11	35.5
Multidrug	MDR	23	74.0
	Non-MDR	8	26.0

MSSA: Methicillin sensitive *Staphylococcus aureus*, MRSA: Methicillin resistant *Staphylococcus aureus*, GSSA: Gentamicin sensitive *Staphylococcus aureus*, GRSA: Gentamicin resistant *Staphylococcus aureus*, MDR: Multi-drug resistance

Distribution of multidrug-resistant *S. aureus* according to the number of antibiotics resisted:

Out of the 23 MDR isolated, 6 (26%), were resistant to three agents out of the six classes tested, 6 (26%) were resistant to five classes, 3 (13.0%) were resistant to four classes while 8 (35.0%) were resistant to all six agents (Table 3).

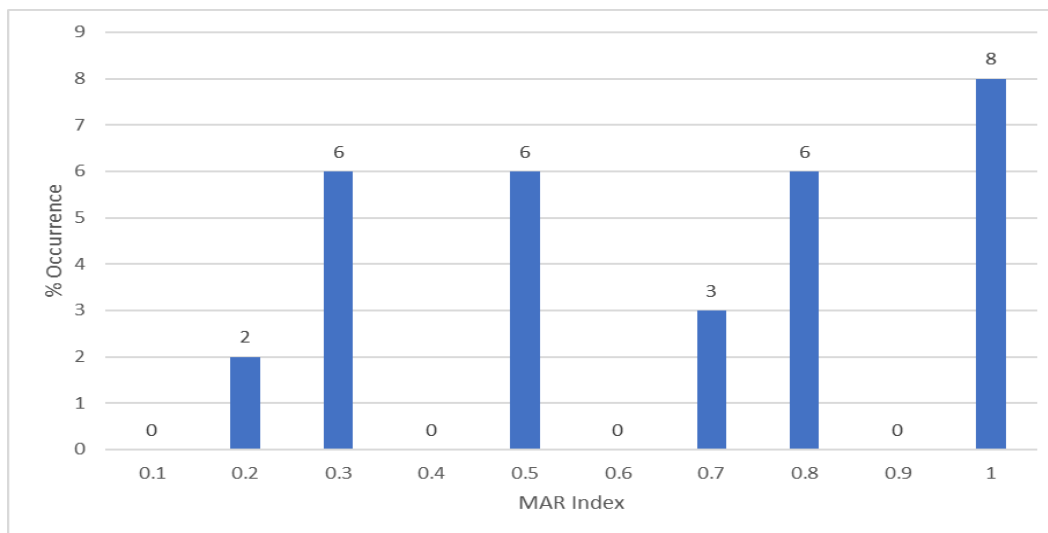
Multiple antibiotic resistance index:

In Fig 2, none of the *S. aureus* isolates had MAR index less than 0.2. The isolates with MARI of 0.2 were 2 (6.45%) while 28 out of 31 (93.5%) had MARI > 0.2. The overall mean MARI value for was 0.7 ± 0.3 .

Table 3: Distribution of multidrug-resistant *S. aureus* according to the number of antibiotics resisted

No of antibiotics	MDR pattern	No of <i>S. aureus</i> isolates	Percentage (%)
3	AMP, CIP, GEN	6	26.0
4	CFX, IMP, ERY, GEN	3	13.0
5	AMP, CFX, CIP, ERY, GEN	6	26.0
6	AMP, CFX, CIP, IMP, ERC, GEN	8	35.0
Total		23	100.0

AMP=Ampicillin, CFX=Cefoxitin, CIP=Ciprofloxacin, IMP=Imipenem, ERC= Erythromycin, GEN=Gentamicin

Fig 2: Frequency distribution of the multiple antibiotic-resistant indices of *Staphylococcus aureus* isolatesTable 4: Association between methicillin and multi-drug resistance among *Staphylococcus aureus* isolates

Bacteria	MDR n (%)	Non-MDR n (%)	Total	χ^2	p value
MRSA	19 (73.0)	7 (27.0)	26	0.105	0.746
MSSA	4 (80.0)	1 (20.0)	5		
Total	23 (74.2)	8 (25.8)	31 (100.0)		

MSSA=Methicillin sensitive *Staphylococcus aureus*; MRSA= Methicillin resistant *Staphylococcus aureus*; MDR=Multidrug resistance

Association of methicillin and multidrug resistance in *S. aureus* isolates:

No statistically significant association was observed between methicillin and multi-drug resistance among the *S. aureus* isolates ($p > 0.05$) (Table 4).

Discussion:

This study evaluated the antibiotic resistance patterns and the MAR index of *S. aureus* isolated from neonatal sepsis cases in a special care baby unit (SCBU) of Turai Yar'adua Maternity and Children's Hospital, Katsina, Nigeria. The findings show high prevalence of AMR, MDR and high MAR index among *S. aureus* isolates of neonatal sepsis, signaling significant antibiotic selection pressure in the hospital environment.

The prevalence of *S. aureus* among culture-positive neonatal sepsis cases in this study is 20.0%, making it the most common bacterial isolate. This is consistent with reports identifying the organism as a major etiological agent of neonatal bloodstream infections in Nigeria and other low- and middle-income settings. A hospital-based study in north-central

Nigeria reported *S. aureus* as the most prevalent organism (13). Another study in southwestern Nigeria reported *S. aureus* as the most common isolated organism (2). In India, *S. aureus* was also the most commonly isolated pathogen (17). However, this is in contrast to the report of the study by Olorukooba et al., (18), in which Gram-negative bacteria (typically *Escherichia coli*) was the predominant organism. The discrepancy in microbial types in neonatal sepsis could be due to differences in geographic region, level of technological advancement available for neonatal sepsis management, and adherence level to infection prevention and control practices. The high prevalence of *S. aureus* underscores its current reemergence as a leading pathogen in neonatal sepsis, highlighting its persistent role in neonatal mortality and morbidity.

The present study observed high resistance of *S. aureus* isolates to erythromycin (87.0%), cefoxitin (83.0%), ampicillin (64.0%) and gentamicin (64.0%). Similar high resistance rates to ampicillin and cephalosporins were reported in a study conducted in the southern part of Nigeria (4). In a study conducted in

Ethiopia, high resistance rate among *S. aureus* isolates was also reported with the highest resistance to ciprofloxacin (19). In addition, a systematic analysis of *S. aureus* resistance in Nigeria reported high resistance rates to ampicillin (68.0%) and third-generation cephalosporins (69.0%) (5). These findings indicate an increasing trend of multidrug resistance among clinical isolates and may reflect widespread empirical antibiotic use and limited antimicrobial stewardship practices.

This study found the prevalence of methicillin resistance among *S. aureus* isolates to be 83.9%. This is higher than the study from Calabar, Nigeria, which reported a prevalence rate of 53.1% (6) and also significantly higher than 12% prevalence rate reported in a study conducted in Uganda (20). A study conducted in Zaria reported MRSA prevalence to be 36% (8). The high rate of MRSA among *S. aureus* population in our study could be the leading factor for therapeutic difficulty and longer hospital stay in the SCBU of the facility.

The high prevalence of MDR (74.2%) observed in our study is higher than that of the study on neonatal infection conducted in north-eastern Nigeria, where MDR *S. aureus* strains accounted for 36.0% of isolates (8), but less than the rate in the study from Ethiopia (21), where MDR rate was more than 90%. A study from China (22) reported MDR rate in *S. aureus* isolates to be higher than 70%, which agrees with the rate reported in our study. This high rate complicates empirical therapy and has been reported to be associated with prolonged hospitalization and increased mortality in neonatal intensive care settings.

The MAR index values obtained in this study were predominantly higher than 0.2, indicating that the isolates originated from environment with frequent antibiotic exposure. A study evaluating MAR indices of *S. aureus* isolates from a tertiary healthcare facility in Nigeria reported MAR indices of the isolates to be higher than 0.2 (6). Another study reported that about 90.8% of *S. aureus* isolates had MAR index higher than 0.2 (3), suggesting sustained antibiotic pressure in clinical environments. In yet another study from Lagos State, Nigeria, MAR index above 0.2 was reported in 77.5% of *S. aureus* isolates (23). A study in Uganda (20) reported 41.0% of *S. aureus* isolates to have MAR index of 0.2. The high MAR index and MDR observed in our study and in other studies may have occurred from frequent empirical antibiotic administration that created 'selection pressure' associated with prolonged

hospitalization in neonatal units.

The lack of association between MDR and MRSA in this study does not undermine the therapeutic significance of MRSA or other resistant bacteria in newborn infections. Methicillin-resistant *S. aureus* continues to be a significant pathogen in neonatal intensive care units, associated with high mortality, morbidity, prolonged hospitalizations, and increased health-care costs (8). Consequently, ongoing surveillance of resistance patterns is crucial for efficient antimicrobial stewardship and prevention of nosocomial infections.

One limitation of this study is the absence of molecular methods for confirmation of MRSA as these isolates were identified using phenotypic techniques, while the gold standard method for identifying MRSA, polymerase chain reaction (PCR) detection of *mecA* gene, was not available. The epidemiology and transmission dynamics of *S. aureus* associated with newborn sepsis would be better understood by future research using molecular methods, such as *mecA* gene identification and genotypic characterization of other resistance determinants.

Conclusion:

Nevertheless, the findings of this study confirm that *S. aureus* was the most common causative bacterial agent of neonatal sepsis in the study area. The study also found high level of phenotypic antibiotic resistance in *S. aureus*, particularly to the most commonly used antibiotics. These results underscore the need for strengthened antimicrobial stewardship programs, routine AMR surveillance, and enhanced infection prevention strategies in neonatal care settings.

Contributions of authors:

HAB conceived and designed the study, collected data, performed laboratory analysis, analyzed the data and drafted the manuscript; BA provided overall supervision of research activities, provided scientific guidance and approved manuscript submission; HMR provided guidance and revised manuscript for scientific accuracy; AS supervised data analysis and interpretation of results and reviewed manuscript for important intellectual contents. All the authors read and approved the manuscript submitted for publication.

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Conflict of interest

No conflict of interest is declared

References:

1. Mustefa, A., Abera, A., Aseffa, A., et al. Prevalence of neonatal sepsis and associated factors amongst neonates admitted in Arbaminch General Hospital, Arbaminch, southern Ethiopia, 2019. *J Pediatr Neonatal Care*. 2020; 10 (1): 1-7. doi:10.15406/jpnc.2020.10.00404.
2. Obadare, T. O., Adejuyigbe, E. A., Adeyemo, A. T., et al. Clinical and bacteriological profiles of neonatal sepsis in a tertiary hospital, south-western Nigeria. *GERMS*. 2023; 13 (2): 137-147. doi:10.18683/germs.2023.1370.
3. Oladipo, A. O., Oladipo, O. G., and Bezuidenhout. C. C. Multi-drug resistance traits of methicillin-resistant *Staphylococcus aureus* and other *Staphylococcus* species from clinical and environmental sources. *J Water Health*. 2019; 17 (6): 930-944. doi:10.2166/wh.2019.177.
4. Uwe Nkoyo, O., Ezenwa, B. N., Fajolu, I. B., et al. Antimicrobial susceptibility and neonatal sepsis in a tertiary care facility in Nigeria: a changing trend? *JAC Antimicrob Resist*. 2022; 4(5): dlac100. doi:10.1093/jacamr/dlac100.
5. Ezech, C. K., Eze, C. N., Dibua, M. E. U., and Emencheta, S. C. A meta-analysis on the prevalence of resistance of *Staphylococcus aureus* to different antibiotics in Nigeria. *Antimicrob Resist Infect Control*. 2023; 12: 40. doi:10.1186/s13756-023-01243-x.
6. Umoh, N. O., Udonkang, M., Akpan, S., Bebia, G., Usanga, V., and Igwebuike, N. Antibiotic resistance indices of methicillin-resistant *Staphylococcus aureus* isolates at a tertiary healthcare facility in Calabar, Nigeria. *Sokoto J Med Lab Sci*. 2024; 9 (1): 150-158. doi:10.4314/sokjmls.v9i1.17.
7. Doubra, O. I., Otokunefor, K., and Agbagwa, O. E. Multiple antibiotic resistance indexing and molecular identification of *Escherichia coli* isolated from clinical and nonclinical sources in Port Harcourt Metropolis, Nigeria. *Pan Afr Med J*. 2025; 51: 11. doi:10.11604/pamj.2025.51.11.38524.
8. Mustapha, S. S., Musa, A. Z., Yusuf, M. S., Aliyu, S., and Abdulkadir, I. Methicillin-resistant *Staphylococcus aureus* infection in neonates: a major concern and a call for action. *Niger Med J*. 2024; 65 (4): 503-511. doi:10.60787/nmj-v65i3-496.
9. Adebisi, Y. A., Jimoh, N. D., Ogunkola, I. O., et al. Prevention of antimicrobial resistance in sub-Saharan Africa: What has worked? What still needs to be done? *J Infect Public Health*. 2023;16(4):632-639. doi:10.1016/j.jiph.2023.02.020.
10. Afunwa, R. A., Ezeanyinwa, J., Afunwa, E. C., Udeh, A. S., Oli, N. A., and Unachukwu. M. Multiple antibiotic resistant index of Gram-negative bacteria from bird droppings in two commercial poultries in Enugu, Nigeria. *Open J Med Microbiol*. 2020; 10: 171-181. doi:10.4236/ojmm.2020.104015.
11. World Health Organization. WHO recommendations for management of serious bacterial infections in infants aged 0-59 days. Geneva: World Health Organization; 2024.
12. Jahan, I., Akter, J., Ferdousi, J., Sultana, Z., and Sabrin, Z. Incidence and clinical outcomes of neonatal sepsis in neonatal intensive care unit admissions: a hospital-based study. *Int J Res Med Sci*. 2026; 14 (2): 630-635. doi:10.18203/2320-6012.ijrms20260253.
13. Olutunde, O., Kareem, I. A., Olateju, K. E., et al. Incidence, bacteriological profile and antibiotic sensitivity pattern of neonatal sepsis in a tertiary health facility in Abuja, North-central Nigeria. *Research Square*. 2021. doi:10.21203/rs.2.21673/v2.
14. Cheesbrough, M. District laboratory practice in tropical countries. Part 2. 2nd edition. Cambridge: Cambridge University Press; 2008.
15. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing. 34th edn. CLSI supplement M100. Wayne (PA): Clinical and Laboratory Standards Institute; 2024.
16. Magiorakos, A. P., Srinivasan, A., Carey, R. B., et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. *Clin Microbiol Infect*. 2012;18(3):268-281. doi:10.1111/j.1469-0691.2011.03570.x.
17. Nazir A, Sana I, Peerzada BY, Farooq T. Study of prevalence and antimicrobial susceptibility pattern of blood culture isolates from a tertiary care hospital of North India. *Int J Res Med Sci*. 2018;6(12):4046-4052. doi:10.18203/2320-6012.ijrms20184905.
18. Olorukooba AA, Ifusemu WR, Ibrahim MS, Jibril MB, Amadu L, Lawal BB. Prevalence and factors associated with neonatal sepsis in a tertiary hospital, North West Nigeria. *Niger Med J*. 2020;61(2):60-66. doi:10.4103/nmj.NMJ_31_19.
19. Sherif M, Abera D, Desta K. Prevalence and antibiotic resistance pattern of bacteria from sepsis-suspected neonates at St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia. *BMC Pediatr*. 2024; 24: 575. doi:10.1186/s12887-023-04399-y.
20. Muwonge, K. M., Ndagire, H., Mulindwa, J., and Twesigye, C. K. Multiple antimicrobial resistance indices of *Staphylococcus aureus* from the nares of goats and slaughterhouse attendants in Kampala City, Uganda: a cross-sectional study. *BMC Microbiol*. 2025; 25: 162. doi:10.1186/s12866-025-03891-y.
21. Solomon, S., Akeju, O., Odumade, O. A., et al. Prevalence and risk factors for antimicrobial resistance among newborns with Gram-negative sepsis. *PLoS One*. 2021;16(8):e0255410. doi:10.1371/journal.pone.0255410.
22. Panpan, F., Gao, K., Yang, J., Li, T., Gong, W., and Wang, Y. Prevalence of multidrug-resistant pathogens causing neonatal early- and late-onset sepsis: a retrospective study from a tertiary referral children's hospital. *Infect Drug Resist*. 2023; 16: 4213-4225. doi:10.2147/IDR.S416020.
23. Osuagwu, C. S., Nmema, E. E., Osinupebi, O. A., Afuwape, O. O., and Binuyo, M. O. Antimicrobial susceptibility pattern and multiple antibiotic resistance index of *Staphylococcus aureus* isolated from health-care workers in a general hospital in Lagos State, Nigeria. *Coast J Sch Sci*. 2022; 4 (1): 743-752.