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Antibiotic Susceptibility Pattern and Multiple Antibiotic Resistance Index of Methicillin-Resistant *Staphylococcus aureus* Isolated from Clinical Specimens in Ika Christian Hospital, Kogi State, Nigeria

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Abstract— *Antibiotic susceptibility pattern of methicillin resistant Staphylococcus aureus (MRSA) isolates from Ika Christian Hospital (ICH), Kogi State, was investigated. This study aimed to determine the prevalence and antibiotic susceptibility pattern of MRSA among clinical isolates at Ika Christian Hospital (ICH) in Ankpa, Kogi State, Nigeria. A total of 225 clinical samples (urine, sputum, wound swabs, and pus) were collected. Staphylococcus aureus isolates were identified using standard microbiological and biochemical methods. Methicillin resistance was confirmed by cefoxitin disc diffusion testing, and prevalence was calculated as the proportion of positive cultures. Antibiotic susceptibility of confirmed MRSA isolates was determined using the Kirby–Bauer disc diffusion method. Out of 225 samples, 222 (98.7%) were positive for S. aureus, of which 158 (71.2%) were confirmed as MRSA. Ciprofloxacin showed 100% sensitivity, and gentamicin 96.0%, while high resistance was observed to cefoxitin (94.7%), oxacillin (91.7%), amoxicillin (89.3%), and cefotaxime (85.3%). The Multiple Antibiotic Resistance Index (MARI) was calculated for each isolate. The MARI values ranged from 0.52 to 0.58, indicating high antibiotic exposure. This study revealed a high prevalence of MRSA with significant multidrug resistance at ICH, highlighting the need for strengthened antimicrobial stewardship and infection control measures.*

Keywords *— Antibiotic susceptibility; antimicrobial resistance; methicillin-resistant Staphylococcus aureus; MARI; multidrug resistance.*

I. INTRODUCTION

Staphylococcus aureus is an important opportunistic bacterial pathogen responsible for a wide spectrum of human diseases ranging from minor skin infections to life-threatening conditions such as septicaemia, pneumonia, osteomyelitis, infective endocarditis, toxic shock syndrome, and food poisoning [1], [2]. The organism commonly colonizes the anterior nares and skin of healthy individuals, serving as a reservoir for both community-associated and hospital-associated infections [3]. Because of its remarkable adaptability and ability to acquire resistance determinants, *S. aureus* has become one of the most clinically significant bacterial pathogens encountered in healthcare settings worldwide.

The rapid emergence and global dissemination of methicillin-resistant *Staphylococcus aureus* (MRSA) have complicated the management of staphylococcal infections over the past several decades. Resistance in MRSA is primarily mediated by the mecA gene, which encodes an altered penicillin-binding protein (PBP2a) with reduced affinity for β-lactam antibiotics, thereby conferring resistance to methicillin and most β-lactam antimicrobial agents [4], [5]. Beyond β-lactam resistance, MRSA frequently exhibits resistance to multiple unrelated classes of antibiotics, resulting in multidrug-resistant strains that significantly reduce therapeutic options and increase treatment costs, morbidity, mortality, and duration of hospitalization [6].

Antimicrobial resistance (AMR) has emerged as one of the most serious public health threats globally. The World Health Organization identifies AMR as a major challenge capable of undermining decades of medical progress if effective interventions are not implemented [7]. Among bacterial pathogens contributing substantially to the global AMR burden, MRSA remains one of the highest-priority organisms because of its widespread occurrence in hospitals, communities, and long-term healthcare facilities [7], [8]. Continuous surveillance of antibiotic resistance patterns is therefore essential to support evidence-based antimicrobial therapy and infection control.

In many low- and middle-income countries, including Nigeria, inappropriate antibiotic use, over-the-counter access to antimicrobial agents, inadequate diagnostic capacity, weak antimicrobial stewardship programmes, and poor infection prevention practices have accelerated the emergence and spread of multidrug-resistant organisms [9], [10]. Several Nigerian studies have reported increasing prevalence of MRSA among clinical isolates, although marked geographical variations exist due to differences in healthcare practices, antibiotic prescribing patterns, and laboratory diagnostic capacity [11], [12].

The Multiple Antibiotic Resistance Index (MARI) provides an important epidemiological tool for assessing the extent of antibiotic exposure within bacterial populations. High

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MARI values (>0.2) indicate that isolates originate from environments where antibiotics are frequently used, thereby reflecting intense selective pressure for antimicrobial resistance [13]. Determination of MARI complements routine susceptibility testing by providing additional information on the potential public health risks associated with resistant bacterial isolates.

Although MRSA has become an important cause of healthcare-associated infections in Nigeria, information regarding its susceptibility profile and multiple antibiotic resistance index remains limited in several secondary healthcare facilities, including Ika Christian Hospital, Ankpa, Kogi State. Such information is essential for guiding empirical antibiotic therapy, strengthening antimicrobial stewardship programmes, and improving infection prevention strategies.

Therefore, this study was undertaken to determine the antibiotic susceptibility pattern and multiple antibiotic resistance index of methicillin-resistant *Staphylococcus aureus* isolated from clinical specimens obtained from patients attending Ika Christian Hospital, Kogi State, Nigeria.

II. Materials and Methods

A. Study Area

This study was conducted at Ika Christian Hospital (ICH), Ankpa, Kogi State, Nigeria. ICH is a secondary healthcare facility that serves patients from Ankpa Local Government Area and neighbouring communities within Kogi State and adjoining states. The hospital receives patients presenting with various infectious diseases and routinely processes clinical specimens through its diagnostic microbiology laboratory. The study location was selected because of the high number of patients presenting with bacterial infections and the limited availability of recent data on methicillin-resistant *Staphylococcus aureus* (MRSA) in the area.

B. Study Design

A hospital-based cross-sectional study was conducted to determine the prevalence of MRSA, evaluate the antibiotic susceptibility profile of the isolates, and determine their Multiple Antibiotic Resistance Index (MARI).

C. Ethical Consideration

Ethical approval for this study was obtained from the appropriate ethical review authority before commencement of sample collection. Permission was also obtained from the management of Ika Christian Hospital. All specimens were collected as part of routine clinical investigations, and patient confidentiality was maintained throughout the study by anonymizing all laboratory records.

D. Sample Collection

A total of 225 clinical specimens were collected from patients attending Ika Christian Hospital during the study period. The specimens consisted of:

- Urine
- Sputum
- Wound swabs
- Pus samples

Samples were collected aseptically by qualified healthcare personnel using standard clinical procedures and transported immediately to the microbiology laboratory for analysis. Each specimen was assigned a unique laboratory identification number before processing.

E. Isolation and Identification of Staphylococcus aureus

Clinical specimens were cultured using standard bacteriological techniques. Appropriate culture media were prepared according to the manufacturer's instructions and sterilized before use. The inoculated plates were incubated aerobically at 37°C for 24–48 hours.

Presumptive *Staphylococcus aureus* colonies were identified based on colonial morphology, pigmentation, Gram staining characteristics, and biochemical reactions. Gram-positive cocci arranged in grape-like clusters were further subjected to catalase and coagulase tests for confirmation. Additional biochemical tests were performed where necessary to differentiate *S. aureus* from other staphylococcal species. Only confirmed *S. aureus* isolates were included in subsequent analyses.

F. Detection of Methicillin-Resistant Staphylococcus aureus

Methicillin resistance was determined using the cefoxitin (30 µg) disc diffusion method following the recommendations of the Clinical and Laboratory Standards Institute (CLSI).

Fresh bacterial suspensions equivalent to 0.5 McFarland turbidity standard were prepared and inoculated uniformly onto Mueller-Hinton agar plates using sterile cotton swabs. A cefoxitin disc (30 µg) was aseptically placed on the inoculated agar surface, and the plates were incubated aerobically at 35–37°C for 18–24 hours.

Following incubation, inhibition zone diameters were measured in millimetres using a calibrated ruler. Isolates were interpreted as methicillin-resistant or methicillin-susceptible according to CLSI interpretive criteria.

G. Antibiotic Susceptibility Testing

Antibiotic susceptibility testing of confirmed MRSA isolates was performed using the Kirby–Bauer disc diffusion method on Mueller-Hinton agar following CLSI guidelines.

Standardized bacterial suspensions equivalent to 0.5 McFarland standard were evenly inoculated onto Mueller-Hinton agar plates. Commercial antibiotic discs representing different antimicrobial classes were aseptically applied to the inoculated plates before incubation at 37°C for 18–24 hours.

After incubation, the diameters of inhibition zones were measured in millimetres and interpreted as Susceptible (S), Intermediate (I), or Resistant (R) according to current CLSI breakpoints.

The antibiotics evaluated included representatives of β-lactams, fluoroquinolones, aminoglycosides, cephalosporins, and other commonly prescribed antimicrobial agents used in the management of *Staphylococcus aureus* infections.

H. Determination of Multiple Antibiotic Resistance Index (MARI)

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The Multiple Antibiotic Resistance Index (MARI) for each MRSA isolate was calculated using the expression:

MAR = x/y where:

x = Number of antibiotics to which an isolate exhibited resistance

y = Total number of antibiotics tested

A MARI value greater than 0.20 was considered indicative of isolates originating from environments with frequent exposure to antimicrobial agents and high antibiotic selection pressure.

I. Statistical Analysis

Laboratory data were entered into Microsoft Excel before statistical analysis. Descriptive statistics were used to summarize the prevalence of *S. aureus*, the proportion of MRSA isolates, antibiotic susceptibility patterns, and MARI values.

Results are presented as frequencies, percentages, tables, and figures. Statistical significance was assessed using the analytical approach described in the thesis, with $P < 0.05$ considered statistically significant where applicable.

III. RESULTS

A. Isolation of Staphylococcus aureus

A total of 225 clinical specimens comprising urine, sputum, wound swabs, and pus samples were processed during the study. Of these, 222 (98.7%) yielded *Staphylococcus aureus*, while only three samples were culture negative. The isolates were confirmed using colony morphology, Gram staining, catalase, and coagulase tests before antimicrobial susceptibility testing.

Table 1.

S.No.			
	Parameter	Number	Percentage (%)
1	Total clinical samples	225	100.0
2	*S. aureus* positive	222	98.7
3	*S. aureus negative*	3	1.3

The isolation rate was consistently high across all specimen types, with wound specimens showing complete recovery of *S. aureus*, while urine, sputum, and pus samples also demonstrated high recovery rates.

B. Prevalence of Methicillin-Resistant Staphylococcus aureus

Among the 222 confirmed *S. aureus* isolates, 158 (71.2%) were identified as methicillin-resistant using the cefoxitin disc diffusion method, whereas 64 (28.8%) were methicillin-susceptible. This indicates a substantial burden of MRSA among clinical isolates recovered from patients attending Ika Christian Hospital.

Table II.

S.No.	Prevalence of MRSA among *Staphylococcus aureus* isolates		
	Characteristic	Number	Percentage (%)
1	Total *S. aureus* isolates	225	100.0
2	MRSA	158	71.2
3	MSSA	64	28.8

C. Antibiotic Susceptibility Pattern of MRSA Isolates

The antimicrobial susceptibility profile demonstrated considerable variation among the antibiotics tested. Overall, the isolates remained highly susceptible to ciprofloxacin and gentamicin, whereas resistance was particularly high against β-lactam antibiotics.

The highest susceptibility was observed with:

- Ciprofloxacin — 100%
- Gentamicin — 96.0%

Conversely, high resistance was observed to:

- Cefoxitin — 94.7%
- Oxacillin — 91.7%
- Amoxicillin — 89.3%
- Cefotaxime — 85.3%

These findings indicate that β-lactam antibiotics have limited usefulness for treating MRSA infections in the study setting, while selected non-β-lactam agents may remain effective when guided by susceptibility testing.

Table III.

S.No.	Overall antibiotic susceptibility profile of MRSA isolates		
	Antibiotic	Susceptibility (%)	Interpretation
1	Ciprofloxacin	100.0	Highly susceptible
2	Gentamicin	96.0	Highly susceptible
3	Cefotaxime	14.7	High resistance
4	Amoxicillin	10.7	High resistance
5	Oxacillin	8.3	High resistance
6	Cefoxitin	5.3	High resistance

D. Multiple Antibiotic Resistance Index (MARI)

The MARI values calculated for the MRSA isolates ranged from 0.52 to 0.58. All values were substantially greater than the threshold value of 0.20, indicating that the isolates originated from environments with frequent exposure to antimicrobial agents and were therefore subjected to strong antibiotic selection pressure.

Table IV.

S.No.	Multiple Antibiotic Resistance Index (MARI) of MRSA isolates	
	Parameter	Value
1	Minimum MARI	0.52
2	Maximum MARI	0.58
3	Interpretation	High-risk source with frequent antibiotic exposure

IV. Summary of Findings

This investigation demonstrated a very high recovery rate of *Staphylococcus aureus* from clinical specimens and a correspondingly high prevalence of MRSA (71.2%). Antimicrobial susceptibility testing revealed that ciprofloxacin and gentamicin retained excellent activity against the isolates, whereas resistance to β-lactam antibiotics—including cefoxitin, oxacillin, amoxicillin, and cefotaxime—was widespread. In addition, the high MARI values indicate that the isolates came from an environment with significant antimicrobial selection pressure, suggesting that multidrug-resistant MRSA is present in the hospital.

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IV. Discussion

The present study investigated the prevalence, antibiotic susceptibility pattern, and multiple antibiotic resistance index (MARI) of methicillin-resistant *Staphylococcus aureus* (MRSA) isolated from clinical specimens obtained from patients attending Ika Christian Hospital, Ankpa, Kogi State. The findings demonstrate a substantial burden of MRSA and indicate that multidrug resistance remains an important clinical and public health challenge in the study area.

A. Prevalence of Staphylococcus aureus and MRSA

An exceptionally high proportion of the clinical specimens yielded *Staphylococcus aureus* (98.7%), with 71.2% of these isolates identified as methicillin-resistant. This indicates that *S. aureus* is a dominant pathogen among the clinical specimens examined and that MRSA constitutes a major proportion of these isolates.

The MRSA prevalence observed in this study is considerably higher than many reports from Nigeria. Previous studies have documented MRSA prevalences of 12.5% among clinical isolates in northwestern Nigeria, 19.2% in Ado-Ekiti, and 40.2% at Obafemi Awolowo University Teaching Hospitals Complex.

Several factors may explain this difference. Variations in MRSA prevalence between studies are influenced by:

- geographical location;
- patient population;
- infection prevention practices;
- antimicrobial prescribing behaviour;
- diagnostic methods; and
- local antimicrobial stewardship programmes.

The high prevalence recorded at Ika Christian Hospital may therefore reflect substantial antibiotic selection pressure within the hospital and surrounding communities, together with ongoing transmission of resistant strains. Similar observations have been reported in several African countries where limited antimicrobial stewardship and inadequate infection prevention programmes contribute to sustained MRSA circulation. Recent African systematic reviews likewise demonstrate that MRSA remains widely distributed across the continent, although prevalence varies considerably between countries and healthcare settings [14], [15].

B. Antibiotic Susceptibility Pattern

The antimicrobial susceptibility profile revealed marked differences between antibiotic classes. Ciprofloxacin demonstrated complete activity against the isolates, while gentamicin also exhibited excellent effectiveness. In contrast, resistance was extremely high against cefoxitin, oxacillin, amoxicillin, and cefotaxime.

This resistance pattern is biologically plausible because MRSA carries the mecA gene, which encodes penicillin-binding protein 2a (PBP2a). The altered penicillin-binding protein has markedly reduced affinity for β-lactam antibiotics, rendering methicillin, oxacillin, cefoxitin, and many cephalosporins ineffective [16], [17].

The complete susceptibility observed with ciprofloxacin suggests that fluoroquinolones may still retain therapeutic usefulness within the study setting. Likewise, the high susceptibility to gentamicin indicates that aminoglycosides continue to provide effective treatment options when supported by laboratory susceptibility testing.

These findings agree with previous Nigerian and international studies that reported high susceptibility of MRSA to ciprofloxacin and gentamicin while documenting persistent resistance to β-lactam antibiotics. Similar observations have been reported by Olufemi *et al.,* Iroha *et al.*, Mbim *et al.*, Eyob *et al.*, and Farzana *et al.*, all of whom noted that resistance among MRSA isolates is concentrated mainly within β-lactam agents, whereas selected non-β-lactam drugs remain comparatively effective [15], [18], [19], [20], [21].

Nevertheless, empirical use of ciprofloxacin should be approached cautiously. Increasing global fluoroquinolone resistance has been reported among MRSA isolates, and inappropriate use may accelerate the emergence of resistant clones. Consequently, antibiotic therapy should continue to be guided by routine antimicrobial susceptibility testing rather than empirical prescription alone.

C. Multiple Antibiotic Resistance Index (MARI)

An important finding of the present study is the uniformly high MARI values (0.52–0.58) recorded among the MRSA isolates. These values are substantially above the accepted threshold of 0.20, indicating that the isolates originated from environments subjected to frequent antibiotic exposure.

High MARI values generally reflect prolonged antibiotic selection pressure and have been associated with healthcare facilities and communities where antimicrobial agents are frequently prescribed or readily available without prescription. Similar interpretations have been reported in earlier studies by Paul *et al.* and Karikari *et al.*, which identified high MARI values as indicators of high-risk contamination sources [22], [23].

The elevated MARI values observed in this study may be explained by several factors commonly encountered in low- and middle-income countries, including:

- indiscriminate antibiotic use;
- self-medication;
- incomplete treatment courses;
- unrestricted over-the-counter antibiotic sales;
- inadequate antimicrobial stewardship;
- circulation of counterfeit or substandard antimicrobial agents.

These practices promote the selection and persistence of resistant bacterial populations, thereby reducing the long-term effectiveness of commonly prescribed antibiotics.

D. Clinical and Public Health Implications

The high prevalence of MRSA combined with widespread multidrug resistance has important implications for patient management and healthcare delivery at Ika Christian Hospital.

Persistent circulation of MRSA may contribute to:

- prolonged hospital admission;
- increased healthcare costs;
- delayed clinical recovery;
- higher treatment failure rates;

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- increased mortality among vulnerable patients.

Routine laboratory diagnosis and susceptibility testing should therefore become an integral component of patient management. Infection prevention strategies—including strict hand hygiene, environmental decontamination, patient screening where appropriate, and antimicrobial stewardship programmes—should be strengthened to reduce MRSA transmission within healthcare facilities. Recent evidence indicates that comprehensive stewardship and infection prevention programmes remain among the most effective interventions for reducing healthcare-associated MRSA infections [24], [25].

E. Strengths and Limitations of the Study

A notable strength of this investigation is that it provides baseline epidemiological data on MRSA in a secondary healthcare facility where published information has been limited. The study also combines prevalence estimates, antimicrobial susceptibility profiling, and MARI analysis, thereby providing a more comprehensive assessment of antimicrobial resistance than prevalence studies alone.

However, several limitations should be acknowledged. MRSA identification relied on phenotypic methods using cefoxitin disc diffusion rather than molecular confirmation of the mecA or mecC genes. Consequently, molecular characterization of resistance determinants and strain typing could not be performed. Furthermore, the study was conducted at a single hospital, which may limit the generalizability of the findings to other healthcare facilities in Nigeria. Future multicentre investigations incorporating whole-genome sequencing or PCR-based detection of resistance genes would provide a more comprehensive understanding of MRSA epidemiology and transmission dynamics.

V. CONCLUSION

This study demonstrated a high prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) among clinical isolates recovered from patients attending Ika Christian Hospital, Ankpa, Kogi State, Nigeria. Of the 222 *Staphylococcus aureus* isolates recovered from 225 clinical specimens, 158 (71.2%) were confirmed as MRSA, indicating that methicillin resistance is widespread within the study setting.

The antimicrobial susceptibility profile showed that ciprofloxacin and gentamicin remained highly effective against the isolates, whereas resistance to cefoxitin, oxacillin, amoxicillin, and cefotaxime was remarkably high. These findings confirm that β-lactam antibiotics have limited therapeutic value for the treatment of MRSA infections in the study area and emphasize the importance of laboratory-guided antibiotic therapy.

Furthermore, the Multiple Antibiotic Resistance Index (MARI) values (0.52–0.58) were considerably above the accepted threshold of 0.20, indicating that the isolates originated from environments characterized by intense antibiotic selection pressure. This observation supports the presence of multidrug-resistant MRSA circulating within the hospital and highlights the need for improved antimicrobial stewardship and infection prevention strategies.

Overall, the study provides important baseline epidemiological data on MRSA in Ika Christian Hospital and contributes to the growing body of evidence on antimicrobial resistance in Nigeria. The findings underscore the need for continuous surveillance, rational antibiotic use, and strengthened infection prevention and control measures to reduce the burden of multidrug-resistant *S. aureus* infections.

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