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Prevalence and Susceptibility Profiles Of *Staphylococcus Aureus* Isolates from Outpatients and Inpatients at UCTH, Calabar, Nigeria

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Abstract- This study determined the prevalence and susceptibility profiles of *Staphylococcus aureus* isolates from patients at University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State, Nigeria. 120 swab specimens from patients were screened for staphylococci using standard microbiological protocol. Coagulase-positive staphylococci (CoPS) isolates were subjected to 16S rRNA sequencing for further identification. By disk diffusion method, antibiotic susceptibility test was evaluated in all the *S. aureus* strains. Results revealed that 46 (38.3%) CoPS and 52 (43.1%) coagulase-negative staphylococci (CoNS) were isolated. Morphological and biochemical characterization showed that of the 120 samples used, 98 (81.7%) yielded staphylococci, out of which only 9 strains of *S. aureus* were identified on the basis of 16S rRNA sequencing. The gender distribution ratio of prevalence of staphylococci was 25:21 (54.3%:45.7%) female to male but with male showing preponderance. There was no significant relationship between sex of patients and prevalence rate of CoPS at significant level ($P \leq 0.05$). All the *S. aureus* strains were highly susceptible to ceftriaxone and cefixime and resistant to vancomycin, penicillin and chloramphenicol. There was significant difference ($p \leq 0.05$) in the resistance patterns of the 9 strains of *S. aureus*. The results proved that *S. aureus* isolates from the clinical samples are relatively resistant to commonly used antibiotics. The outcome of this study is useful in moderating the right prescription of antibiotics against *S. aureus* infections especially in hospital settings.

Keywords*: Susceptibility, prevalence, resistance*

I. INTRODUCTION

Staphylococcus aureus is a commensal bacterium and also an important opportunistic human pathogen causing a variety of community and nosocomial infections, such as bacteremia, sepsis, endocarditis, pneumonia, osteomyelitis, arthritis and skin diseases, etc. [1]. It can survive for hours to weeks, or even months, on dry environmental surfaces. It is frequently a constituent of the skin and nasal flora, and the primary reservoir for *S. aureus* is the nasal cavity. About one third of the human population is long-term carriers of *S. aureus* [2]. Among staphylococcal infections, *S. aureus* is the most common species that causes infections. The organism has the inherent capacity to infect other tissues when first line defenses or barriers (e.g. skin or mucosal lining) have been breached [3].

To control this pathogenic bacterium and many others, antibiotics are often used since the accidental discovery of penicillin by Alexander Fleming in 1928 [4], with a considerable recorded success in clearing infections caused by these organisms. However, *S. aureus* has developed several strategies (natural and/or acquired) to overcome antibiotics [5]. Indeed, the acquired resistance is the most spread in bacteria and has now become a global phenomenon. Antimicrobial resistance is one of our most serious health threats; infections from resistant bacteria are now too common and some pathogens have even become resistant to multiple types or classes of antibiotics. One of these highly equipped bacteria is *S. aureus*, which has become a major public health concern as a result of the steadily increasing incidence of antimicrobial resistance [6, 7].

The acquired mechanisms of resistance to antibiotics include the antibiotic target modification mechanism especially observed in Gram-positive cocci [8]. Amongst these target modification mechanisms, the production of a new penicillin-binding protein (PBP) such as PBP2a or PBP2 with little affinity for beta-lactams and leading to resistance to methicillin is distinguished [9]. The best-known mechanism of resistance to beta-lactam drugs is the production of beta-lactamases, which is not chromosomal but rather plasmid-mediated and can be non-inducible or inducible with antibiotics [10, 11]. The emergence of resistant staphylococci strains to beta-lactams by this mechanism is therefore of concern since the beta-lactam antibiotics are considered very efficacious with few side effects [12]. In West Africa, staphylococcal infections are widespread and are often associated with surgical site infections, otitis media, urogenital infections, etc. [13].
Studies have been carried out on the prevalence and antimicrobial resistance of *S. aureus* strains isolates from patients in hospitals on a global scale. For example, a

study carried out in Addis Ababa, Ethiopia, 79 *S. aureus* isolates were recovered from 54(57.4%) patients. The isolates were resistant to ampicillin (100%), oxacillin and cefoxitin (68.4%, each), clindamycin (63.3%), cephalothin (59.5%), tetracycline (57%), sulfamethoxazole + trimethoprim and bacitracin (53.2%, each), and erythromycin (51.9%). Resistance to two or more antimicrobials was recorded in 74 (95%) of the isolates, while resistance to 3 or more antimicrobials was detected in 65(82.3%) of the isolates [14]. In another research conducted in Baghdad, Iraq, which was aimed out isolating *Staphylococcus aureus* from different clinical samples and determined the antibiotics susceptibility pattern of *S. aureus*; results revealed that out of 300 clinical samples 103 isolates (34.33 %) were staphylococci and out of these isolates 40 (38.83 %) were *S. aureus*. According to antibiotics sensitivity test, resistance to gentamycin was 15%, erythromycin 55%, clindamycin 35% and 2.5% of isolates had intermediate resistance to teicoplanin 5%, tetracycline 47.5% rifampicin 10%, trimethoprim/sulfamethoxazole and tobramycin 5%, while 12.5 % of isolates had intermediate resistance to the last one. 5% of isolates resisted vancomycin, while 10% had intermediate resistance to it. 92.5 % of isolates were sensitive to levofloxacin, while 7.5 % had an intermediate resistance to it. 100% of isolates were sensitive to moxifloxacin, linezolid and tigecyclin and 97.5 % of isolates were sensitive to nitrofurantoin [3].

In Nigeria, an investigation carried out in Sokoto to determine the incidence and antibiotic susceptibility profile of *Staphylococcus aureus* isolates from wounds of patients at a Specialist Hospital indicated that a total of twenty (20) *Staphylococcus aureus* were isolated from thirty-eight (38) wound specimens collected. Out of which, five percent (5%) were found to be MRSA. The isolates were resistant to the antibiotics tested and susceptible only to gentamicin (85%), norfloxacin (80%) and amoxiclav (50%) [15]. In another similar study conducted in Abia State University Teaching Hospital, Aba, Nigeria, aimed at evaluating the frequency and antibiotic susceptibility pattern of *Staphylococcus aureus* isolated from various clinical specimens of out-patients showed that 104 *Staphylococcus aureus* strains were isolated from the 424 clinical specimens (24.5% prevalence rate) with 40 (38.5%) of the isolates being methicillin resistant *S. aureus* (MRSA) and 64(61.5%) being methicillin susceptible *S. aureus* (MSSA). Generally, the isolates showed high resistance to ampicillin (76.9%), penicillin G (81.7%), Nalidixic acid (72.1%), chloramphenicol (70.1%) and were considerably sensitive to gentamycin (68.3%), ciprofloxacin (61.5%) and cefpodoxime (66.3%) [16].

Most patients (especially in developing countries like Nigeria) with clinical signs usually indulge in indiscriminate use of antibiotics before consulting the physicians when the severity of the disease could no longer be controlled. On the other hand, the physicians often treat the patients with broad-spectrum antibiotics before appropriate diagnostic measures are carried out [17]. These widespread indiscriminate use and inappropriate prescription of antibiotics in the treatment of bacterial infections are in no small measure contributing to the emergence and dissemination of bacterial resistance to the commonly used antimicrobial agents [18]. Therefore, there is need for continuous and regular antimicrobial resistance surveillance in the country in order to guide treatment prescriptions and to provide adequate control strategies to tackle this public health problem.

In Calabar, Cross River State, Nigeria, the place of surgical wound infections and otitis media diseases are no less important. These infections are of public health relevance and also constitute economic burden on patients who are infected. Unfortunately, however, there is a dearth of studies on the prevalence and susceptibility profiles of Coagulase-positive *Staphylococcus aureus* isolated from patients in hospitals around the south-south region of Nigeria. In order to fill these gaps and to monitor the evolution of bacterial resistance, this study was initiated to determine the prevalence and susceptibility profiles of coagulase-positive *Staphylococcus aureus* isolates from human clinical specimens in University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State, Nigeria.

II. MATERIALS AND METHODS

Study design and subjects

This investigation was carried out at University of Calabar Teaching Hospital, Calabar, Cross River State, Nigeria, from October, 2018 to September, 2019. The hospital provides diverse services for patients from different parts of the country. Therefore, the study design was hospital-based in which outpatients from ear, nose, and throat (ENT) ward and inpatients from the general surgical and orthopaedic wards were captured in the study. Patients with clinical manifestations of surgical site infections having surgical wound with pus discharge, signs of sepsis as well as those diagnosed for surgical site infection from general surgical and orthopaedic wards were recruited into the study. These patients were hospitalized for various period and were treated with different antibiotics including ceftriaxone, metronidazole, vancomycin, cefixime, oxacillin, gentamicin, chloramphenicol, etc. In addition, patients with acute and chronic otitis media with clinically proven discharge from ENT outpatient ward were randomly recruited. These patients were those that had history of recent treatment with ciprofloxacin, amoxicillin+clavulanic acid, tetracycline, etc., and just a few that had no history of recent antimicrobial therapy. Only patients who volunteered willingness to participate in the study were involved.

Sample collection

120 swabs of human clinical specimens were aseptically collected from 120 outpatients and inpatients. The breakdown of samples was as follows: wound swab from those with surgical site infection (i.e., 18 from general

surgical ward, and 37 from orthopaedic ward), and 65 ear swabs from patients with otitis media showing clinical symptom of ear discharge were collected. The wound site and ear were first cleaned with sterile saline to remove any purulent debris. Sterile cotton swab was moistened with normal saline and rotated three times on the wound surface and ear opening and placed in test tubes containing 10 ml of sterile Trypton Soya Broth (TSB), (BD, Diagnostic Systems, Heidelberg, Germany). The samples were transported in ice packed coolers to the Microbiology Laboratory of the Cross River University of Technology, Calabar, within 1-2 hours of collection and were immediately incubated at 37°C overnight.

Culture and identification of *Staphylococcus aureus*

After overnight growth in TSB, loopful of the suspension was evenly streaked into mannitol salt agar (MSA) (Oxoid, Basingstoke, Hampshire, England) and incubated at 37 °C for 24 hours. Bacterial colonies that yielded characteristic small, round, yellow or golden yellow colour with the MSA were selected as presumptive staphylococci. These isolates were subjected to routine morphological and biochemical characterization tests such as gram stain, catalase and coagulase to differentiate from coagulase-negative staphylococci. The isolates from fermented plates were further identified by haemolysis, oxidase, IMViC, triple sugar iron agar test, urease test, MacConkey agar, DNase test using standardized protocol. The 16S rRNA sequencing was carried out for further identification of the isolates at species level [19, 20, 21].

Antimicrobial susceptibility testing

Antimicrobial susceptibility test for nine (9) *Staphylococcus aureus* strains was carried out against a panel of 15 antimicrobials using Kirby Bauer disc diffusion method described by the Clinical Laboratory Standard Institute, (CLSI) [22]. The bacterial culture was grown in TSB for 4–5 h at 37 °C and the inoculum size was adjusted with 0.5 McFarland standard. A sterile swab stick was dipped into a test tube containing the inoculum, squeezed against the inside of the test tube to remove excess fluid and then streaked all over the surface of the plate containing Mueller Hinton agar medium (MHA) (Oxoid, Basingstoke, England) to obtain a uniform spread in all direction. The plates were allowed to stand for 10 minutes for the agar surface to dry. Using a cooled previously flamed forceps, the commercially prepared antibiotic discs were picked and placed at least 50mm apart from the edge of the plate to prevent overlapping of the growth inhibition zone. The plates were allowed to stand for few minutes before incubation at 37^{o} C for 18-24 hours. After incubation, the diameters of the zone of growth inhibition were measured in millimetre using a transparent meter rule and interpreted according to the British Society for Antimicrobial Chemotherapy (BSAC) standards [21]. The growth inhibition zones per antibiotic were measured in triplicate and the standard error determined. The following antibiotics with disc (Sensi-Discs, Becton, Dickinson and Company, Sparks, MD) concentrations in micrograms (μg) were used for the study: oxacillin (OX: 10), penicillin G (P: 10), ampicillin (PN: 30), Kanamycin (KA: 20), amoxicillin+clavulanic acid (AMC: 30), ceftriaxone (CRO: 30), chloramphenicol (C: 30), cefuxime (CEF: 30) ciprofloxacin (CIP: 10), erythromycin (E: 10), gentamicin (GM: 10), amoxil (AX; 20), sulphamethoxazole-trimethoprim (SXT: 25), tetracycline (TE: 30), and vancomycin (VAN: 30).

Data analysis

The Chi-square test was employed to verify association of sex of patients with carriage rate of coagulase-positive staphylococci. One-way analysis of variance was used to compare the difference in the level of resistance amongst the different strains of *Staphylococcus aureus*. The difference between the means was considered significant at $p \leq 0.05$.

III. RESULTS

Table 1 shows the results of prevalence of staphylococci in the 120 samples collected from both outpatients and inpatients in the UCTH Calabar. Forty-six (46/38.3%) coagulase-positive staphylococci (CoPS) and 52 (43.1%) coagulase-negative staphylococci (CoNS) were isolated. Of the 18 General Surgery samples, 16 (88.8%) yielded staphylococci, with 12 (66.6%) CoPS and 4 (22.2%) coagulase-negative staphylococci. In the Orthopedic ward, of the 37 samples (wound swabs), 30 (81.1%) yielded staphylococci, of which 10 (27%) were CoPS and 20 (54.1%) were CoNS. Similarly, of the 65 ENT (otitis media) samples, 52 (80%) were staphylococci isolates, with 24 (37%) CoPS and 28 (43.1%) CoNS. In summary, of the 120 samples collected in the study, 98 (81.7%) yielded staphylococci bacteria, comprising both CoPS and CoNS. Also, of the 120 samples, forty-six (46) Gram positive and coagulase positive Staphylococci were isolated, of which only 9 strains were identified as *Staphylococcus aureus* based on morphological, biochemical characterisation and 16S rRNA sequencing.

Table 1: Carriage and prevalence of staphylococci from different sampling groups

Study group	**Total**	**Staphylococci**					**Total**	**%**
	COPS	No.	%	CONS	No.	%		
General Surgery Ward	18	12	66.6		4	22.2	16	88.8
Orthopaedic Ward	37	10	27		20	54.1	30	81.1
ENT Ward (Otitis Media)	65	24	37		28	43.1	52	80.0
Total	**120**	**46**	**38.3**		**52**	**43.1**	**98**	**81.7**

COPS: Coagulase-positive staphylococci, CONS: Coagulase-negative staphylococci, ENT: Ear, Nose and Throat.

Table 2: Male/Female ratio of staphylococci carriage amongst different sampling groups

Sampling group	Gender	Staphylococci		Total
		No.	%	Male 25 (54.3%)
General Surgery Ward	Male	8	6.6	Female 21 (45.7%)
	Female	4	3.4	
Orthopaedic Ward	Male	6	5.0	
	Female	4	3.4	
ENT Ward (Otitis media)	Male	11	9.2	
	Female	13	10.7	
Total		**46**	**38.3**	

Table 2 shows the results of male/female ratio of staphylococci amongst different sampling groups. Here, of the 12 (66.6%) of CoPS obtained from General Surgery ward, 8(6.6%) of the isolates were from the males while 4 (3.4%) were from the females. Also, of the 10 (37%) CoPS isolated from orthopedic ward, males had 6 (5.0%) while female had 4 (3.4%). From the ENT ward which had 24 (37.0%), 11 (9.2%) were from the males while 13 (10.7%) were obtained from the females.

Table 3: Antibiotic susceptibility profile of Gram-positive *Staphylococcus aureus* strains

Mean zones of inhibition measured in millimetres									
Antibiotic	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**
Vancomycin	10±1.5(R)	09±1.2(R)	11±1.4(R)	10±1.8(R)	12±1.5(R)	08 ±1.2(R)	09±1.5(R)	11±1.2(R)	12±1.8(R)
Chloramphenicol	11±1.4(R)	10±1.2(R)	11±1.4(R)	12±1.4(R)	14±1.2(I	10±1.7(R)	12±1.5(R)	11±1.7(R)	14±1.4(I)
Amoxi.+Clav. Acid	21±1.7(S)	15±1.4(I)	20±1.5(S)	21±1.2(S)	19±1.5(S)	22±1.8(S)	11±1.4(R)	20±1.2(S)	21±1.7(S)
Erythromycin	24±1.4(S)	15±1.5(I)	14±1.5(I)	12±1.8(R)	16±1.4(I)	14±1.2(I)	16±1.5(I)	15±1.7(I)	16±1.5(I)
Ampicillin	20±1.4(S)	25±1.2(S)	23±1.7(S)	20±1.8(S)	26±1.2(S	25±1.2(S)	24±1.4(S)	19±1.2(S)	15±1.5(I)
Penicillin	10±1.2(R)	11±1.2(R)	11±1.8(R)	09±1.4(R)	08±1.2(R)	11±1.4(R)	12±1.2(R)	08±1.5(R)	09±1.8(R)
Kanamycin	11±14(R)	13±1.8(I)	14±1.2(I)	12±1.5(R)	13±1.7(I)	14±1.4(R)	14±1.5(I)	15±1.5(I)	11±1.8(R)
Ciprofloxacin	26±1.2(S)	26±1.8(S)	24±1.2(S)	20±1.5(S)	26±1.7(S)	23±1.4(S)	15±1.5(I)	12±1.5(R)	25±1.8(S)
Cefixime	29±1.2(S)	31±1.5(S)	24±1.2(S)	20±1.5(S)	21±1.7(S)	22±1.4(S)	27±1.7(S)	26±1.7(S)	30±1.2(S)
Amoxi	25±1.5(S)	12±1.5(R)	25±1.4(S)	26±1.7(S)	24±1.8(S)	23±1.4(S)	25±1.7(S)	29±1.2(S)	26±1.4(S)
Oxacillin	21±1.5(S)	19±1.2(S)	12±1.5(R)	20±1.7(S)	14±1.8(I)	21±1.4(S)	20±1.7(S)	22±1.8(S)	28±1.4(S)
Ceftriaxone	21±1.5(S)	19±1.4(S)	24±1.5(S)	25±1.5(S)	23±1.7(S)	25±1.2(S)	28±1.5(S)	26±1.8(S)	27±1.4(S)
Tetracycline	14±1.5(I)	25±1.4(S)	22±1.2(S)	21±1.5(S)	15±1.7(I)	29±1.2(S)	26±1.5(S)	18±1.2(S)	29±1.8(S)
Sulphamethox.+Trim.	18±1.4(S)	19±1.2(S)	18±1.5(S)	22±1.5(S)	29±1.7(S)	20±1.4(S)	20±1.5(S)	14±1.8(I)	22±1.8(S)
Gentamycin	26±1.4(S)	24±1.2(S)	21±1.5(S)	16±1.5(I)	26±1.7(S)	19±1.4(S)	23±1.4(S)	22±1.8(S)	27±1.8(S)

S=Sensitive; R=Resistance; I=Intermediate; ± =Standard error.

The result in Table 3 shows that isolates of bacterial strains were variously susceptible to many antibiotics that were tested against them. It was also found that there were variations in the resistance pattern of the strains for each antibiotic. Thus, all the 9 isolates of *Staphylococcus aureus* strains exhibited resistance to penicillin, and to the polypeptide antibiotic vancomycin. On the contrary, 8 strains showed sensitivity to semisynthetic antibiotic ampicillin while 7 strains showed sensitivity to oxacillin. Intermediate sensitivity was seen in 7 strains for the macrolide antibiotic, erythromycin. All the strains showed sensitivity to the third-generation antibiotics, cephalosporins, cefixime and ceftriaxone. Seven strains were sensitive to amoxicillin+clavulanic acid, ciprofloxacin and tetracycline. Only one strain was found to show intermediate susceptibility to amoxicillin+clavulanic acid, ampicillin, ciprofloxacin, oxacillin, sulphamethoxazole+trimethoprim, and gentamycin. Seven *Staphylococcus aureus* strains showed resistance to chloramphenicol, two strains showed intermediate sensitivity to the same antibiotic. Each aminoglycoside antibiotics such as erythromycin, oxacillin, vancomycin, kanamycin and chloramphenicol showed varying resistance pattern. Eight strains were sensitive to gentamycin and one strain showed intermediate sensitivity. Four strains exhibited resistance to kanamycin while 8 strains were sensitive to sulphamethoxazole+trimethoprim.

IV. DISCUSSION

The objective of the current study was to determine the prevalence and susceptibility profiles of coagulase-positive *Staphylococcus aureus* isolates from human clinical specimens at the University of Calabar Teaching Hospital, Calabar, Cross River State, Nigeria. According to the results obtained, the overall prevalence of coagulase-positive staphylococci amongst the patients in the three wards used in the study was 46 (38.3%) out of 120 samples collected. Of this number, 9 strains were identified as *Staphylococcus aureus* based on morphological, biochemical characteristics and 16S rRNA sequencing. *Staphylococcus aureus* is the most significantly disseminated pathogen worldwide in both humans and animals, as well as in the environment because of its ubiquitous nature. The bacterium has remarkable adaptability and versatility, which has equipped it as a commensal and as a pathogen [23,24].

Staphylococcal infections have been prevalent in various healthcare institutions where they are referred to as nosocomial infections, and communities for many past decades. There is a plethora of literature on this infection in both developed and underdeveloped countries across the globe [2,25]. The result of this study is consistent with the findings of a similar investigation conducted in the southeast of Nigeria [4], who reported isolation rate of 37.8% from 424 clinical samples evaluated. Also, similar prevalence of *S. aureus* was reported from patients with pus/wound discharge at Gondar University hospital in north Ethiopia [26], and from ear discharges from Hawassa Hospital, southern Ethiopia [27]. In this study, coagulase-positive staphylococci were not detected in some of the patients. This could be due to direct topical application of antimicrobials to the infection site which might have affected growth of bacteria from this site. The other possible reason could be the real absence of *S. aureus* from infection site [28].

The gender prevalence ratio in this study was 25:21 (54.3%:45.7%), with a male preponderance. This could be due to small sample size in the current study and difference in category of patients involved. A similar prevalence was observed in a study among healthy volunteers of Gulf Medical University and Gulf Medical College Hospital, Ajman, UAE, with the isolation of *S. aureus* amongst the males and females showing a 35:27 ratio, respectively [2]. Statistically, this study proved that there was no significant relationship between sex of patients and carriage rate of coagulase-positive staphylococci at significant level ($P \leq 0.05$).

Development of resistance to antibiotics by *Staphylococcus aureus* has become a major public health concern worldwide most probably due to the fact that they are very often associated with hospital and community-acquired infections. However, these bacteria have been found to exhibit a great deal of versatility in their behaviour towards antibiotics as some strains have been observed to evolve resistance to most commonly used antibiotics. There was variation in the range of resistance pattern observed for each antibiotic. All the 9 isolates of *Staphylococcus aureus* strains showed resistance to penicillin and the polypeptide antibiotic vancomycin. On the contrary, 8 strains showed sensitivity to semisynthetic antibiotic ampicillin and 7 strains were sensitive to oxacillin. Intermediate sensitivity was seen in 7 strains for the macrolide antibiotic, erythromycin. All the strains of *S. aureus* showed sensitivity to the third generation cephalosporins, cefixime and ceftriaxone while seven strains were sensitive to amoxicillin+clavulanic acid, ciprofloxacin and tetracycline. Seven (7) *Staphylococcus aureus* strains exhibited resistance to chloramphenicol, two strains showed moderate resistant to the same antibiotic. Eight strains were sensitive to gentamycin and one strain showed intermediate sensitivity. Four strains exhibited resistance to kanamycin. The antibiotic susceptibility pattern is presented in Table 3. The observed varying range of resistance pattern could be due to localized infections with different strain of *S. aureus* at the different sites of specimen collection and the fact that the patients were exposed to different types of antimicrobials before this study was conducted. Another possible reason could be the difference in level of previous exposure to antimicrobial agents, which might not be uniform in terms of concentration/dosage. This observation agrees with the findings **[**14**]**, which evaluated the antimicrobial resistance profile of *Staphylococcus aureus* isolated from patients with infection at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia.

Penicillin inhibits synthesis of bacterial peptidoglycan, which of course, is the major cell wall component that gives rigid mechanical stability due to its highly cross-linked lattice wall structure in the bacterium [29]. In this study, 9 isolates of *Staphylococcus aureus* strains from clinical specimens were highly resistant to penicillin; and the resistance may be due to the excessive rational or irrational use of the penicillin. The inherent weakness of penicillin is because of the attack of ring nucleus by beta-lactamase produced in *Staphylococcus aureus* [30]. Resistance to beta-lactam antibiotics by *S. aureus* have been reported in several empirical studies [2,24,25].
Also, in this study, vancomycin was found to be resistant to all isolates of *S. aureus* strains from the clinical samples. The development of resistance occurs through different mechanisms such as chromosomal mutations or through plasmids, and it may also be due to the linkage of resistance genes from old antibiotics to the latest ones which most often are available in different markets and thus commonly sold over the counter [31]. *Staphylococcus aureus* strains from clinical samples have been found to be vancomycin-resistant [32]. However, 100% sensitivity to vancomycin in multidrug resistant *Staphylococcus aureus* have also been reported [33].

Of particular interest is that 8 strains in this study were sensitive to ampicillin and 7 strains were sensitive to oxacillin contrary to reports from previous studies where resistance to ampicillin and oxacillin was observed to be 82.2% and 88.5% of *S. aureus* isolates from patients with surgical site infection at Debre Markos Referral Hospital, northwest Ethiopia, respectively, [34]. On the other hand, it is in agreement with the report, which asserts that 90% sensitivity to ampicillin and oxacillin was recorded in *S. aureus* strains isolates from patients admitted to Felege Hiwot referral Hospital, North Ethiopia [35]. Such difference could be attributed to variation in patient hospital stay, level of infection control practices by health facilities, and previous exposure of patient to antimicrobials [36].

In our present investigation, seven strains showed resistance to chloramphenicol while 4 strains were resistant to Kanamycin. *S. aureus* has been shown to be resistant to chloramphenicol in other studies [37]. Kanamycin resistance has proven to be due to a plasmid encoded determinant [38]. Very unlike the report of the previous study where, erythromycin was said to have

proved effective antibiotic against *Staphylococcus aureus* [39], in this study erythromycin moderate sensitivity strains were observed which may make the treatment for staphylococcal infections difficult. It was also observed in this investigation that all the strains were sensitive to the third generation cephalosporins ceftriaxone and cefixime. The sensitivity of *Staphylococcus aureus* strains isolated from patients to ceftriaxone and cefixime has also been reported [23]. Statistical analysis revealed that there was significant difference ($p \leq 0.05$) in the resistance patterns of the 9 strains of *S. aureus* isolated from the patients.

V. CONCLUSION

This study has provided a foresight into the prevalence and susceptibility profiles of *S. aureus* strains isolated from patients at the said hospital. In the light of the findings of this study, it can be concluded that *S. aureus* is a major agent of both surgical wound and ear infections at the University of Calabar Teaching Hospital, Calabar, Nigeria, due to its prevalence rate. Most of *S. aureus* strains isolated exhibited resistance to at least one or more of the antibiotics while a few strains were completely resistant to some of the test drugs especially the beta-lactam antibiotics with the exception of ampicillin, cefixime and ceftriaxone. However, since the investigation involved limited wards in a single hospital besides small sample size, the result may not represent the whole hospital situation and the region or country in general.

RECOMMENDATION

The finding necessitates the implementation of measures to control spread of multi-drug resistant strains in hospital and possibly communities. Examples of such measures are as follows: ameliorating antimicrobial stewardship through routine monitoring of antimicrobial sensitivity of circulating strains and eschewing or reducing empirical therapy, effective infection control practices, training of health personnel and patients on the risk of antimicrobial resistance.

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Ethics approval and consent to participate

Study protocol was approved by the Ethical Committee of Cross River State Ministry of Health, Calabar. Individual verbal informed consent was obtained from all adult participants and the parents or guardians of all children who participated in the study following adequate explanation about the purpose of the study.

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