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Prevalence and Antibiotic Susceptibility Patterns of Methicillin-Resistant Staphylococcus Aureus (MRSA) Isolated from Some Communities and Hospitals in Nsukka, Nigeria

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Abstract:
Methicillin-resistant Staphylococcus aureus (MRSA) is a human pathogen that has emerged as a serious public health problem both in hospital and community settings. This study was conducted to determine the prevalence and antimicrobial resistance patterns of MRSA from healthcare and community environments. A total of 900 samples comprising 600 hospital and 300 community samples were examined. S. aureus was isolated and identified from hospital and community samples using standard laboratory procedures and MRSA strains were identified using Kirby Bauer disk diffusion method. A total of 505 (56.1%) isolates of Staphylococcus aureus were recovered out of which 295 (32.8%) were MRSA. Generally, among the hospital samples, S. aureus was recovered from 367 (61.2%) samples out of which 209 (56.9%) were MRSA while among the community samples, S. aureus was recovered from 150 (50%) samples, out of which 86 (28.7%) were MRSA. From individual hospitals, MRSA had prevalence between 30.0% and 50.0% but the differences were not significant (p>0.05). Similarly, the differences in prevalence among different sample types (urine, wound, swabs etc.) were not significant (p>0.05). In the five communities sampled, MRSA had prevalence values between 26.7% and 30.9% but again no significant differences were apparent. The MRSA isolates exhibited a high rate of resistance to most of the antibiotics tested. Most of the isolates were resistant to at least one antibiotic and 190 isolates (64.4%) were resistant to four or more antibiotics. The most resisted antibiotics for hospital samples were amoxicillin (88.5%); pefloxacin (70.8%); cotrimoxazole (62.2%); penicillin G (59.3%) and oxacillin (64.6%) while the least resisted were erythromycin (31.1%); ciprofloxacin (42.1%); gentamycin (46.9%); cefuroxine (45%) and streptomycin (37.3%). For the community isolates, the most resisted were penicillin G (65.1%); oxacillin (74.4%); and ceftriaxone (75.6%) while the least resisted were cotrimoxazole (40%); ciprofloxacin (31.4%) and amoxicillin (26.7%). The E test for the detection of minimum inhibitory concentration (MIC) ranged from 0.75 μg/ml to 8 μg/ml. This study showed that there is high prevalence of MRSA in Nsukka, that the MRSA strains have developed resistance to other classes of antibiotics in addition to β-lactams.

Keywords: *Staphylococcus aureus, MRSA, E test, prevalence, antimicrobial susceptibility*

1. Introduction

Staphylococcus aureus is a Gram-positive bacterium capable of infecting virtually every tissue of the body and causing infections ranging from minor skin infections to life-threatening infections, such as bacteremia, endocarditis, necrotizing pneumonia and toxic shock syndrome (TSS). *S. aureus* is a major cause of health care associated infections, estimated to be responsible for 13.8 per 100 hospitalizations in US hospitals in 2005 (Klein *et al.,* 2007). Staphylococcal infection remains a major health challenge in several countries, with huge resultant adverse effect ranging to life-threatening diseases such pneumonia, bacteremia to high mortality cases (Asadollahi et al., 2018). The increasing prevalence of antibiotic resistant *S. aureus,* has emerged as a serious public health issue both in the hospital and community settings (Maha *et al*., 2009). Initially, treatment of *Staphylococcus aureus* infections in the 1940s involved a beta-lactam antibiotic, penicillin (Geddes, 2008). However, by the end of the 1940s, 50% of *Staphylococcus aureus* strains were resistant to penicillin in the USA (Lowy, 1998). In 2002, 90% of *Staphylococcus aureus* strains isolates found in hospitals worldwide were resistant to penicillin (Greenwood *et a*l., 2002). Methicillin, a semisynthetic penicillin, was introduced in 1960 as an alternative to penicillin therapy for the treatment of *Staphylococcus aureus* infection (Chambers, 2001). However, the identification of methicillin -resistant *Staphylococcus aureus* (MRSA) strains was reported in 1961, within a year after its introduction as an anti-staphylococcal drug (Lowy, 2003).

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a strain of S*taphylococcus aureus* that is resistant to the antibacterial activity of methicillin and other related antibiotics of the penicillin class which include dicloxacillin, naticillin, oxacillin, amoxicillin etc. and the cephalosporins. Methicillin-resistant *Staphylococcus aureus* (MRSA) is a serious threat to hospitalized patients globally and it now represents a challenge for public health, as community –associated infections appear to be on the increase in both adults and children in various regions and countries (Layton *et al.,* 1995). The transmission of *Staphylococcus aureus* in hospitals is often a result of exposure of patients to health-care workers who are *S. aureus* carriers or from infected patients (Lowy, 1998). *Staphylococcus aureus* is a significant pathogen because of the extracellular virulence factors that facilitate pathogenesis and colonization of the host (Greenwood *et a*l., 2002). Treatment of *Staphylococcus aureus* has become difficult due to the ability of the bacterium to rapidly develop multi-drug resistance (Lowy, 1998).

Methicillin-resistant *Staphylococcus aureus* (MRSA) were initially prevalent in hospitals before 1980; however, the spread of the resistant strains to the community followed soon (File, 2008). Between 1993 and 2003, novel strains of MRSA that were phenotypically and genotypically distinct from the parent health-care associated MRSA (HA-MRSA) were identified in the community suggesting evolution of the original MRSA (Naimi *et al*., 2003). These strains of MRSA became known as community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) (Center for Disease Control (CDC), 2003; Naimi *et al*., 2003). Recently, CA-MRSA strains have been recorded to cause infections in health-care facilities demonstrating the ecological fitness and emergence of these stains in different clinical setting (Popovich *et al.,* 2008). The dissemination of these CA-MRSA strains in both the health-care facilities and communities has become a health-care concern worldwide (Ribeiro *et al*., 2007). Due to this dissemination, monitoring of both HA-MRSA and CA-MRSA are essential in order to implement adequate and efficient infection control measures to prevent potential outbreaks of these strains. MRSA could be isolated from a variety of frequently touched surfaces including wiping cloths, dishtowels as well as badges, lanyards and coats worn by health care workers (Scott *et al*., 2009). Contaminated environmental surfaces have been shown to play a significant role during outbreaks in long term care facilities (Dudhagara *et al*., 2011). MRSA may be aerosolized in the droplet nuclei from a coughing resident and also survive in infectious dust generated from the patient's articles and materials, hence improper discard or storage of hospital formites has a great concern towards the new infection of MRSA (Huang *et al*., 2006).

Community acquired MRSA (CA-MRSA) infections which were first described in small series of adult and pediatric patients presenting skin and soft tissue infections (SSTIs), pneumonia, or bacteremia have become a significant public health threat (Peters *et al*., 2013), in Nigeria and abroad. Since 1930, the epidemiology of *S. aureus* has changed dramatically and MRSA has reached epidemic levels in both hospital and community settings (Stenehjem and Rimland, 2013). The epidemiological success of CA-MRSA strain is believed to stem from combination of antibiotic resistance fitness at low cost with extraordinary virulence, allowing these strains infect otherwise healthy individuals and spread sustainably in the population (Perveen *et al*., 2013). The major reservoirs of *S. aureus* in hospitals are colonized or infected in-patients and colonized hospital workers. Carriers of *S. aureus* are at risk of developing endogenous infections or transmitting infections to health care workers and patients (Nwoire *et al*., 2013). Transient carriage of the organism on the hands of health care workers accounts for the major mechanism for patient-to-patient transmission (Javid *et al*., 2006). Despite the global incidence of MRSA, however, its incidence and spread in Nigeria is not yet well documented. A study in Zaria reported 69% prevalence among healthy women (Onanuga *et al*., 2005). Another study reported a prevalence of about 16% in Southwestern Nigeria (Shittu *et al*., 2011) while another study in Jos recorded a prevalence of 49% among apparently healthy individuals in the community (Ajoke *et al*., 2012). It has also been reported that one of the cardinal features of the rapid emergence of MRSA in many parts of the world is the dissemination of specific clones, which has contributed to the accelerated increases in the incidence of MRSA (Ko *et al*., 2005). Consequently, surveillance for this emerging pathogen and investigation of the genetic relatedness of strains isolated from different environments is of great importance. However, information and data on the prevalence and antibiotic susceptibility patterns of MRSA strains in Nsukka is insufficient despite the established fact that MRSA is a significant problem. This study is aimed at determining the prevalence and antimicrobial resistance patterns of strains of methicillin-resistant *Staphylococcus aureus* from healthcare and community environments in Nsukka, Enugu State, Nigeria.

2. Materials and Methods

2.1. Sample Collection

Different clinical samples such as urine, sputum, wound, nasal swab and swab of different parts of hospital wards were collected for this study from four different hospitals in Nsukka environment. These hospitals were labelled as A, B, C and D and the samples collected are shown in Table 1. These samples were processed as soon as possible after collection.

2.2. Processing of Samples

One loopful of each sample (urine, sputum) and swab swabs were inoculated into mannitol salt agar plates which had been prepared according to manufacturer's instruction. These plates were incubated at 37^{0}C for 24 h. The characteristic isolates were aseptically identified and characterized using established microbiological methods which include Gram Stain, Colonial Morphology, Catalase, Coagulase and hemolysis.

Staphylococcus aureus colonies were stored in nutrient agar stands at 4^{0}C for further use. Methicillin resistant S*taphylococcus aureus* (MRSA) were determined by growing the S*taphylococcus aureus* strains isolated on Muller Hinton agar with oxacillin. Those strains that were resistant to oxacillin were termed MRSA.

		Hospitals				
S/N	Samples	Bishop Shanahan	St. Anthony	Nsukka Medical Clinic	Good Shepard	Total
1	Urine	100	30	30	40	200
2	Sputum	10	15	10	15	50
3	Wound	30	20	10	20	80
4	Nasal swabs	200	12	20	18	250
5	Fomites	8	4	4	4	20
6	Total	348	81	74	97	600
		Communities				
		Nsukka	Opi	Nru	Ede Oballa	Obukpa
7	Nasal swabs	76	60	55	60	49
		Total				300

Table 1: Pattern of Sample Collection from Different Sources

2.3. Antimicrobial Susceptibility Testing

The antimicrobial susceptibility pattern of the *S. aureus* isolates was determined using Kirby-Bauer disc diffusion method using Mueller Hinton agar with an inoculum density equivalent to 0.5 Macfarland turbidity standard (Cheesbrough, 2002). All the isolates were tested for sensitivity to twelve antibiotics. The inoculum density is equivalent to 1.5 x 10^8 bacteria per ml. 0.1 ml of the standardized overnight culture of each isolate was used to flood the surface of Mueller Hinton agar plates; excess drained off and allowed to dry while the lid was in plate. Standard antibiotic discs were aseptically placed at reasonable equidistance on the inoculated Mueller Hinton agar plates and allowed to stand for 1 h. The plates were then incubated at 37^{0}C for 24 h. The diameter of the zone of inhibition produced by each antibiotic was measured, recorded and the isolates were classified as resistant, intermediate and sensitive based on the standard interpretative chart updates according to the current NCCLS standard (BSAC, 2002; NCCLS, 2002). Antibiotic discs used with their concentrations are as follows:

Oxacillin (1µg), penicillin G (10µg), pefloxacin (10µg), Gentamycin (10µg), Ampicillin/Cloxacillin (30µg), Cefuroxine (20µg), Amoxacillin (30µg), Ceftriaxone (25µg), Ciprofloxacin (10µg), Streptomycin (30µg), Cotrimaxole (30µg) and Erythromycin (10µg) (Oxoid, UK).

2.4. Minimum Inhibitory Concentration (MIC) of Oxacillin

The minimum inhibitory concentrations of oxacillin against some MRSA isolates were determined using E test oxacillin strip (Biomerieux, Spain) that contained different concentrations ranging from 0.016 µg/ml -256 µg/ml, on Muller Hinton Agar with an inoculum density equivalent to 0.5 MacFarland turbidity standard (Cheesbrogh, 2000). A 0.1 ml alqurt of the standardized overnight culture of each isolate was used to flood the surface of Mueller Hinton agar plates; excess drained off and allowed to dry while the lid was in plate. The E test oxacillin strip was aseptically placed on the inoculated Mueller Hinton agar plates and allowed to stand for 1 h. The plates were then incubated at 37^{0}C for 24 h. Different MIC values were recorded based on the zone of inhibition.

2.5. Statistical Analysis

Frequencies were obtained and percentages were calculated for study variables. Chi-square and T-test were used to calculate probabilities and determine significance. A P – value of less than or equal to 0.05 will be considered to be statistically significant ($p< 0.05$).

3. Results

3.1. Isolation and Characterization of Staphylococcus Aureus

Out of 900 samples examined, a total of 505 (56.1%) isolates of S*taphylococcus aureus* were recovered consisting of 115 (57.5 %) from urine, (30.6%) from sputum, 50 (62.5%) from wound, 12 (60 %) from formites, 148 (59.2%) from nasal swabs of hospital personnel and 150 (50%) from nasal swabs of individuals from communities. These results are shown in Table1. A total of 295 (32.8%) isolates of MRSA were recovered from different samples comprising 80 (40%) urine, 16 (32%) sputum, 26 (32.5%) wound, 7 (35%) formites, 80 (32%) nasal swabs from hospital personnel, and 86 (28.8%) nasal swabs from communities (Table 2).

All the 505 (100%) S*taphylococcus aureus* isolates were haemolytic**,** fermented mannitol, catalase positive and are Gram positive cocci in clusters. A total of 495 (98%) of the isolates were coagulase positive and 10 (2%) were coagulase-negative (Table 3).

3.2. Prevalence of Staphylococcus Aureus in Samples According to Hospitals Sampled

Out of 600 clinical samples collected from different hospitals 367 (61.2%) were *Staphylococcus aureus* (Figure 1). Among the hospitals visited, 150(75%) of *Staphylococcus aureus* was isolated from hospital personnel in Bishop Shanahan hospital followed by *Staphylococcus aureus* isolated from wound swabs 19(63.3%); sputum, 5(50%); urine, 50(50%) and formites (50.4%) in the same hospital. At St Anthony's hospital, 17(56.7%) of *Staphylococcus aureus* from urine, sputum, 9(60%); wound, 10(50%); hospital personnel, 6(50%) and formites 2(50%). At Nsukka Medical clinic, 14(46.7%) of

Staphylococcus aureus from urine; sputum, 6(60%); wound, 10(50%); hospital personnel, 11(53%) and formites 2(50%). At Good Shepherd hospital, 12(30%) of *Staphylococcus aureus* from urine; sputum, 6(60%); wound, 12(60%); hospital personnel, 10(55.6%) and formites 2(50%). It was observed that there was no significant difference (p>0.05) between hospitals and no significant difference between sample types except in Good Shepherd hospital where there was low occurrence in urine.

3.3. Prevalence of MRSA in Different Samples According to Hospitals Sampled

0ut of a total 600 clinical samples collected from different hospitals, 209 (34.8%) were MRSA (Figure 2).

3.4. Prevalence of Staphylococcus Aureus and Methicillin-Resistant Staphylococcus Aureus (MRSA) in Samples Collected from Hospitals Sampled

Prevalence of *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* (MRSA) in samples from different hospitals were shown in Table 4. A total of 600 clinical samples were collected from different hospitals in which 367 (61.2%) were *Staphylococcus aureus* and 209 (34.8%) were methicillin-resistant *Staphylococcus aureus* (MRSA).

3.5. Prevalence of S. Aureus and MRSA Isolated from Human's Resident in Communities

Prevalence of *S. aureus* and MRSA in different communities sampled was shown in Figure 3. Out of 300 nasal swabs collected from different communities in Nsukka metropolis, 150 (50%) were *Staphylococcus aureus* and 86 (28.7%) were MRSA. It was observed that no significant difference between communities (p>0.05) except in Nsukka, Ede-Oballa and Obukpa where MRSA accounted for more than 50% of the *Staphylococcus aureus* isolated.

Type of Sample	Number Sampled (%)	Number Positive for S. aureus (%)	Number Positive for MRSA (%)
Urine	200 (22.2)	115 (57.5)	80 (40)
Sputum	50 (5.6)	30 (60)	16 (32)
Wound	80 (8.9)	50 (62.5)	26 (32.5)
Hospital Formites	20 (2.2)	12 (60)	7 (35)
Hospital personnel	250 (27.8)	148 (59.2)	80 (32)
Community	300 (33.3)	150 (50)	86 (28.7)
Total	900	505 (56.1)	295 (32.8)

Table 2: Prevalence of Staphylococcus Aureus and Methicillin Resistant Staphylococcus Aureus (MRSA) in Different Samples

Characterization	Number of Isolates Positive (%)	Number of Isolates Negative (%)
Hemolysis	505 (100%)	0 (0%)
Mannitol fermentation	505 (100%)	0 (0%)
Gram reaction	505 (100%)	0 (0%)
Catalase	505 (100%)	0 (0%)
Coagulase	495 (98%)	10 (2%)

Table 3: Summary of Morphological and Metabolic Characteristics of the Isolates

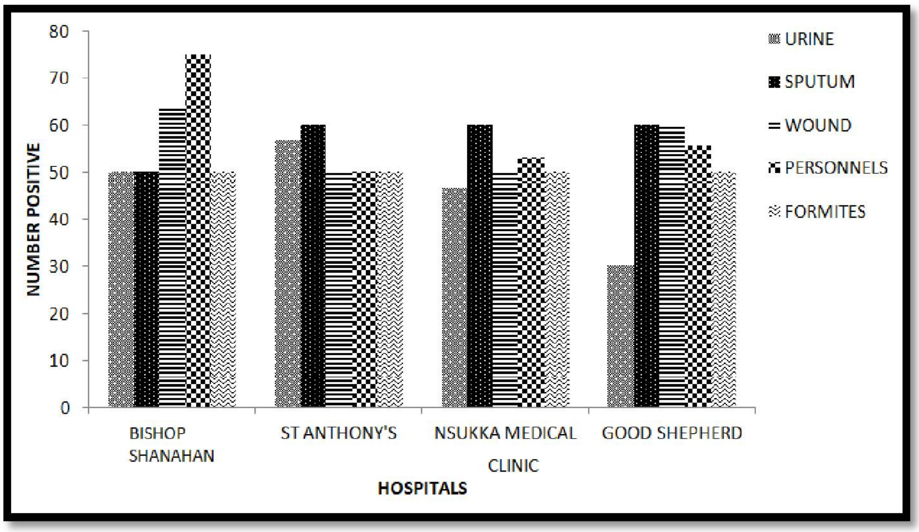

Figure 1: Prevalence of Staphylococcus Aureus in Different Samples According to Hospitals Sampled

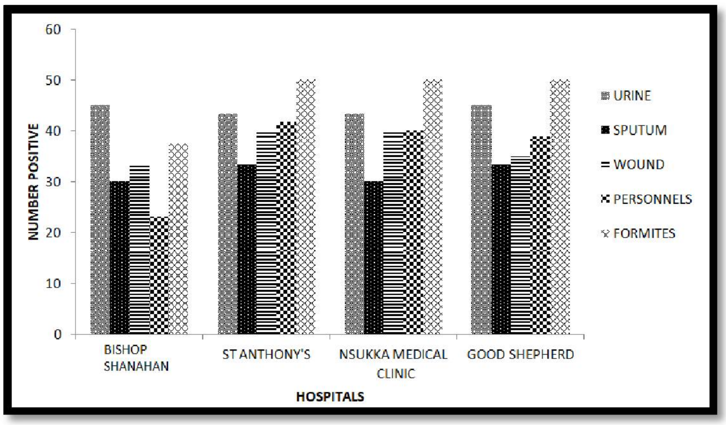

Figure 2: Prevalence of MRSA in Samples According to Hospitals

Hospital	Different Samples Collected/Number	Number of Positive for *S. aureus* (%)	Number of Positive for MRSA (%)
Bishop Shanahan	Urine 100	50 (50)	45 (45)
	Sputum 10	5 (50)	3 (30)
	Wound 30	19 (63.3)	10 (33.3)
	Hospital personnel 200	150 (75)	46 (23)
	Surfaces of the hospitals 8	4 (50)	3 (37.5)
St Anthony's hospital	Urine 30	17 (56.7)	13 (43.3)
	Sputum 15	9 (60)	5 (33.3)
	Wound 20	10 (50)	8 (40)
	Hospital personnel 12	6 (50)	5 (41.7)
	Surfaces of the hospital 4	2 (50)	2 (50)
Nsukka Medical clinic	Urine 30 Sputum 10 Wound 20	14 (46.7) 6 (60) 10 (50)	13 (43.3) 3 (30) 4 (40)
	Hospital personnel 20	11 (53)	8 (40)
	Surfaces of the hospital 4	2 (50)	2 (50)
Good Shepherd Hospital	Urine 40 Sputum 15 Wound 20	12 (30) 9 (60) 12 (60)	18 (45) 5 (33.3) 7 (35)
	Hospital personnel 18	10 (55.6)	7 (38.9)
	Surfaces of the hospital 4 600	2 (50) 367(61.2)	2 (50) 209(38.8)

Table 4: Prevalence of Staphylococcus Aureus and Methicillin-Resistant Staphylococcus Aureus (MRSA) in Samples from Different Hospitals

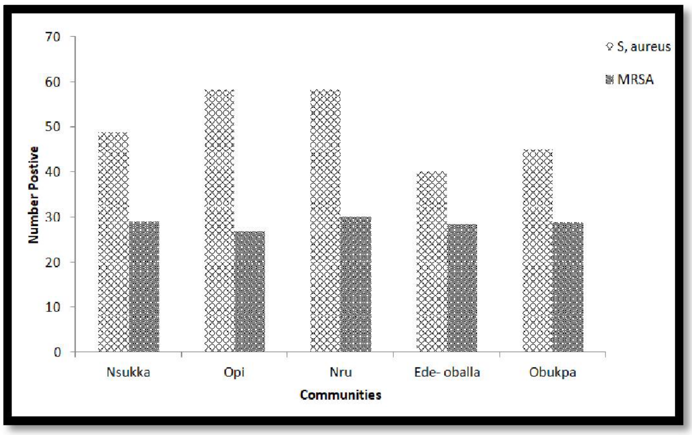

Figure 3: Prevalence of S. Aureus and MRSA in Samples from Different Communities Sampled in Nsukka

3.6. Antimicrobial Resistance Testing

The results of antibiotic susceptibility testing of *Staphylococcus aureus* and MRSA isolates from hospitals and communities are shown in figure 4 and figure 5. From the results, it was observed that in the hospital, *S. aureus* isolates showed high resistance to amoxicillin (60.6%), pefloxacin (57.2%), penicillin G (55.8%) and oxacillin (66.2%) while MRSA showed high resistance to penicillin G (59.3%), oxacillin (64.6%), amoxicillin (88.5%), ampicillin/cloxacillin (49.8%), pefloxacin (70.8%) and cotrimoxazole (87.3%). In the communities, it was observed that *S. aureus* isolates showed high resistant to penicillin G (63.3%), ampicillin/cloxacillin (56.7%), cefuroxine (61.3%), ceftriaxone (75.3%) while MRSA showed less resistance to erythromycin (46.5%), ciprofloxacin (31.4%), and cotrimoxazole (14.0%). The prevalence of multidrug resistance in the MRSA isolates is shown in figure 6.

3.7. Minimum Inhibitory Concentrations (MIC) of Oxacillin (E test)

The results of the minimum inhibitory concentrations of some MRSA isolates were recorded. It was observed that these MRSA isolates had different MIC ranging from 0.75 µg/ml-8 µg/ml (Table 5 and Figure 6).

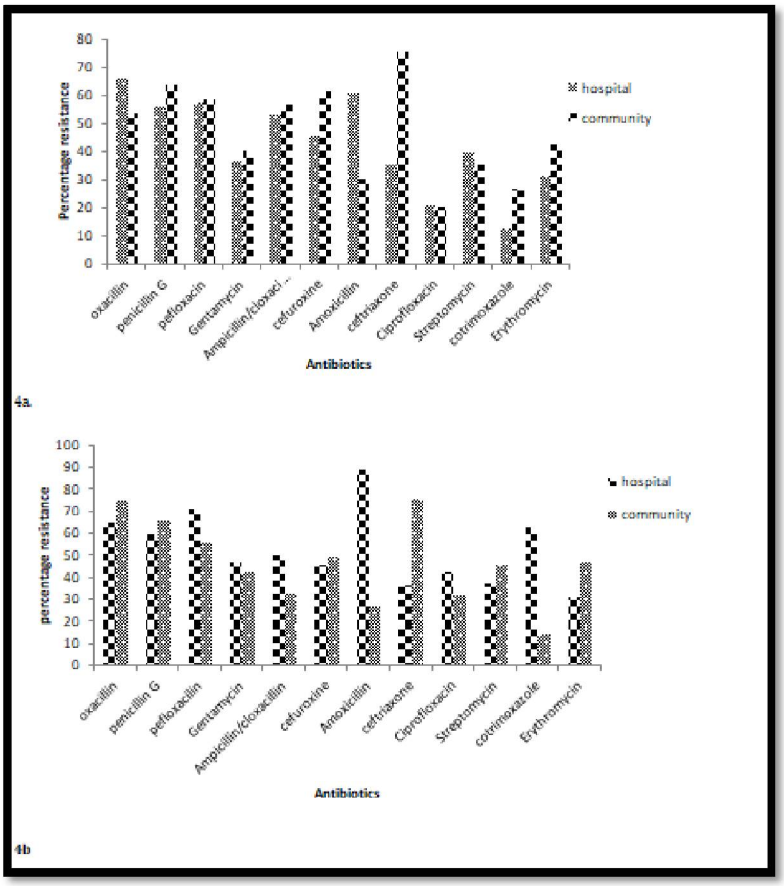

Figure 4: Resistance Pattern of S. Aureus and MRSA from Different Hospitals and Communities in Nsukka

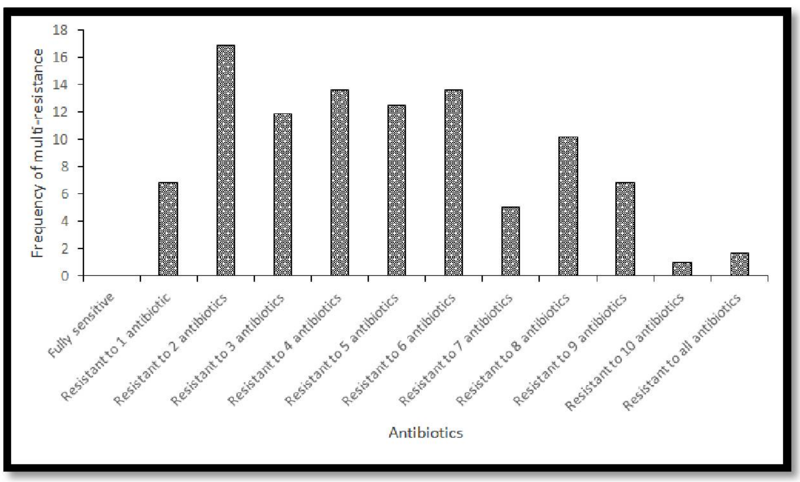

Figure 5: Prevalence of Multiple Drug Resistance among 295 MRSA Isolates

MRSA Isolates	MIC (µg/ml)	Sources
1	No inhibition	Wound
2	1.0	Wound
3	0.75	wound
4	1.0	Wound
5	5.0	Wound
6	4.0	Wound
7	5.0	Wound
8	4.0	Wound
9	4.0	Wound
10	6.0	Wound
11	3.0	Wound
12	8.0	Wound
13	1.5	Wound
15 36 41 48	1.0 1.0 1.5 1.0	Wound Hospital formite Hospital formite Urine
88	3.0	Nasal
89	1.0	Nasal

Table 5: Different MIC Values of MRSA Isolates from Various Clinical Specimens

Figure 6: Minimum Inhibitory Concentration (MIC) of MRSA Isolates at 4µg/Ml Using E-Test Oxacillin Strip

4. Discussion

In recent times, methicillin-resistant *Staphylococcus aureus* (MRSA) has acquired distinction among the *Staphylococcus aureus* strains, because it is associated with distinct epidemiology, particularly morbidity and mortality; and it continues to be a major public health problem worldwide (Al-Ruaily and Khahl, 2011; Liu, 2009). Assessment of the prevalence of this important pathogen and the risk to populations is therefore important for patient care and infection control. In this study, *Staphylococcus aureus* was recovered from 505 out of 900 samples giving a prevalence of 56.1%. Of these, 295 isolates (32.8%) were MRSA as determined by their resistance to oxacillin. MRSA accounted for 58.9% of hospital *S. aureus* isolates and 57.3% of community isolates, but the general prevalence of MRSA in the hospital and community were 34.8% and 28.7%, respectively. The isolation of MRSA from both hospital and community samples is consistent with reports that MRSA, previously acquired almost exclusively in hospitals, is gaining increasing importance in the community (Salmenlinna *et al*., 2002; Popovich *et al*., 2007; Chatterjee *et al*., 2009; Kouyos *et al*., 2013). However, the high prevalence, particularly in humans resident in community sampled is worrisome, because it is contrary to suggestions by researchers that although isolation of MRSA is no longer limited to hospital patients, the prevalence of MRSA colonization in the community remains low (Salmenlinna *et al*., 2002; Chatterjee *et al*., 2009) It is also noteworthy that other studies in Nigeria have recorded MRSA prevalence values of between 16 to 69% (Onanuga *et al*., 2005; Shittu *et al*., 2011; Ajoke *et al*., 2012; Ikeagwu *et al*., 2008). It is one of the most infectious agents with high prevalence in various communities and health care institutions (Akindele *et al*., 2010). However, there is an increasing prevalence of *S. aureus* as a urinary tract infectious etiologic agent with an alarming rate of developing antimicrobial resistance (Nwanze *et al.,* 2007, Akortha and Ibadin, 2008). This present study revealed the prevalence rate of 57.5% of *Staphylococcus aureus* from urine in the hospitals visited. The observation is in line with the findings of Onanuga and Awhowho, (2012) and Nwoire *et al*. (2013) who reported the prevalence rate of 33.6% and 24.8% of *Staphylococcus aureus* from urine respectively. This finding also supports the finding of Akerele *et al.* (2000) who reported the recovery rate of 35.6% of *S. aureus* in Benin-city, Nigeria, and also the findings of Okonko *et al.* (2009) in Ibadan, Nigeria, and Manikandan *et al.* (2011) in India, who reported the organism as the second most prevalent pathogen in urinary tract infections. Thus, these recent findings confirm *S. aureus* as an important etiologic agent in urinary tract infections. The prevalence of *S. aureus* from urine might be attributed to the level of staphylococcal infection in this study area and poor personal hygiene amongst others. There was a prevalence rate of 40% MRSA in urine in this present study. This is in contrast with the study of Pacio *et al.,* (2003) and Mylotte *et al.* (2002) who reported a prevalence rate of 13% and 11% MRSA in urine respectively from nursing home patients. These findings have important implications for patient care. Because urinary catheterization is a major risk factor for *S. aureus* bacteriuria, reducing the prevalence of catheterization should be beneficial. Efforts to limit the acquisition of MRSA by catheterized patients through appropriate infection-control measures can be useful. The prevalence of *S. aureus* and MRSA in urine samples across hospitals was not significantly different from each other (p >0.05). *S. aureus* has been implicated as an important pathogen in respiratory tract infections and detection of its present in sputum is essential for satisfactory antibiotic treatment. The present study revealed the prevalence rate of 60% *S. aureus* from sputum from different hospitals. This study is also in line with the work of Zhang *et al*. (2012) who reported a prevalence rate of 51.7% *S. aureus* from sputum of asthmatic patients. It was observed that bacteria do colonize the lower air ways of asthmatic patients. However, there may be various reasons why patients with severe asthma may be predisposed to greater bacterial colonization of their lower airways (Zhang, *et al*., 2012). Innate Immune responses may be defective particularly in severe asthma. There was no significant difference (p >0.05) among the samples across hospitals. MRSA is also an important pathogen of the respiratory tract infections. This work revealed the prevalence of 32% MRSA in sputum in all the hospitals visited. This work agrees with the work of Zhang *et al*. (2012) who reported a prevalent rate of 34.5% MRSA in sputum of asthmatic patients. The prevalence of MRSA in sputum was not significantly difference among the hospitals visited (p>0.05).

This study observed a prevalence of 62.5% of *Staphylococcus aureus* and 32.5% of MRSA from wound in the hospitals visited. This result is in contrast with the work of Nwoire *et al*. (2013) who reported that 31.6% of *Staphylococcus aureus* was isolated from wound. This work is in agreement with the reports of Rajadurai-pandi *et al*. (2006), who reported isolation rate of MRSA (31.6%) from wound and Perwaiz *et al*. (2007) who reported isolation rate of MRSA (32%) from wound. The prevalence of *Staphylococcus aureus* and MRSA were not significantly different among various clinical specimens in different hospitals (p>0.05). The prevalence of *Staphylococcus aureus* and MRSA in wound could be attributed to poor personal hygiene and exposure of the wounds, which might have made it more prone to contamination and infection. Furthermore, most people in this area tend to treat their wounds on their own or employ services of ill-trained quacks before seeking medical attention which could account for the level of colonization by *Staphylococcus aureus* in wounds in this study. In hospitals however, surfaces with hand contact are often contaminated with nosocomial pathogens (Boyce *et al*., 1997), and may serve as vectors for cross transmission. A single hand contact with a contaminated surface results in a variable degree of pathogen transfer (Kramer *et al*., 2006).

A prevalence of 60% *Staphylococcus aureus* and 35% MRSA were recovered from the formites in the hospitals visited. This shows that formites may serve as a potent reservoir of *Staphylococcus aureus* and MRSA which may transmit the infection in community and thus the development of community acquired MRSA infection is increasing rapidly. This study is in line with Ezeonu and Ayogu, (2013) who reported a prevalence rate of 20-30% of *S. aureus* from individuals as well as formites in all the hospitals sampled. Earlier reports have also suggested that the MRSA strains can survive and be isolated from formites (Neely and Maley, 2000; Sakaguchi *et al*., 2008; Williams and Davis, 2009). Staphylococcal infections are often spread directly by skin contact with a colonized or infected person or animal, but may be spread indirectly through formites. Even formites are very vital reservoir of the various infections other than *Staphylococcus* and it depends on the types of formites and the route from where they are derived (Pravin *et al*., 2011). Hence, environmental sources and formites cannot be ignored.

Staphylococcus aureus is a human pathogen which lives as a commensal on the anterior nasal mucosa of 30-50% of the general population (Casewell, 1998). The anterior nares have been shown to be the main reservoir of *Staphylococcus aureus* in adult and children (Hassain *et al*., 2001; Casewell, 1998). Nasal carriage of *Staphylococcus aureus* has been demonstrated to be a significant risk factor for nosocomial and community acquired infection in variety of populations (Klugtmans *et al*., 1997). Self-inoculation is thought to occur when organisms from the nose colonize other areas of the skin, leading to infection through skin lesions (Suggs *et al*., 1999; Casewell, 1998). In the current study, of the 250 health-care workers screened, 59.2% of *Staphylococcus aureus* strains and 32% of MRSA strains were isolated from the nasal swabs of hospital personnel. *S. aureus* and MRSA carriage in the health-care workers in this study was relatively high compared with other work reported in other countries (Albrich and Habarth,2008; Dimitrov *et al*., 2003; Rioux *et al*., 2007; Shobha *et al*., 2005). From this result, it was observed that these hospital personnel were colonized with these strains of organisms. Some researchers reported that the hands of healthcare personnel were transiently colonized and MRSA is mainly transmitted to the patient in the hospital (Mulligan *et al.,* 1993; Rao, 1998 and Pittet *et al.,* 2000). Moreover, proper hand hygiene may prevent the spread of MRSA among the hospital personnel and community individuals. Community-acquired MRSA infections are becoming more widely reported, although the prevalence of MRSA carriage overall remains low in healthy persons in the communities (Harbarth *et al*., 2005; Salgado *et al*., 2003).

The prevalence of *Staphylococcus aureus* and MRSA among various individuals in different communities were determined. Continuous spread of staphylococcal infection in several communities is now becoming a threat to the populace and mostly the children (Akinduti *et al*., 2021). The study showed that *Staphylococcus aureus* is high in Nsukka (48.7%), Opi (58.3%), Nru (58.2%), and less in Obukpa (44.9%). MRSA strains were low in all the communities screened: Nsukka (28.9%), Opi (26.7%), Nru (30.1%), Ede-Oballa (28.3%) and Obukpa (28.6%). The overall study showed high prevalence of *Staphylococcus aureus* (50%) and low prevalence of MRSA (28.71%) in the communities screened (Table 4). Data reported in other studies worldwide show a similar result among healthy persons in the community (Salgado *et al*., 2003; Shobha *et al*., 2005). This study is in line with INSAR (2013) who reported the overall prevalence of MRSA in their study to be 42% in 2008 and 40% in 2009 and Gonsu *et al*. (2013) also reported a prevalence of 40.6% of MRSA. This low prevalence of MRSA in this study is in contrast with the work of Orji *et al*. (2012), Scott *et al*. (2011) and Onanuga *et al*. (2005) who reported a high prevalence of MRSA in the communities screened. Also, the high prevalence of *Staphylococcus aureus* in communities in this study is in line with the work of Ibe *et al*. (2013) who reported a prevalence of *Staphylococcus aureus* to be 82.1% but contrary to the low prevalence of MRSA in this study, the authors reported a MRSA prevalence of 60.7%. The presence of *Staphylococcus aureus* and MRSA in the communities screened could be due to living in crowded household and having household members MRSA-colonized persons which are unique characteristics of most rural communities in developing countries and this has been found to increase the risk of becoming colonized by MRSA (Shen *et al*., 2013). This result showed that there is need for enlightenment programme in these communities concerning proper hand washing and self-hygiene. The rate of colonization of *Staphylococcus aureus* and MRSA in these individuals showed that these individuals need to be screened before exposure to the hospital to avoid outbreak and cross infection.

In this study, in vitro resistance pattern of this Gram-positive pathogen was assessed from different clinical specimens isolated from hospitalized patients and nasal swabs from community individuals. Methicillin-resistant *Staphylococcus aureus* is generally characterized by its highly antibiotic-resistant nature, being typically resistant to β-lactam antibiotics. Two phenotypic strains of MRSA have been identified, Hospital-acquired MRSA (HA-MRSA) and Community-acquired MRSA(CA-MRSA), and it has been suggested that they have distinct epidemiology and antibiotic resistant patterns, hence the use of antibiotic-resistance patterns as a phenotypic testing tool to distinguish between hospital- and community-acquired strains (Salmenlinna *et al*., 2002; Popovich *et al*., 2007; Kouyos *et al*., 2013). It has been reported that in addition to resistance to the β-lactams, HA-MRSA strains exhibit resistance to other classes of antibiotics, whereas the community-acquired strains are more susceptible to multiple classes of antibiotics (Popovich *et al*., 2007; Kouyos *et al*., 2013). In this present study, it was observed that *Staphylococcus aureus* isolated from clinical samples in hospitals showed high resistance to oxacillin (66.2%), penicillin G (55.8%), pefloxacin (57.2%) and amoxicillin (60.6%). This high resistance of *Staphylococcus aureus* to oxacillin (66.2%) is in line with Kalsoon and Hameed, 2006 and Farzana and Hameed, 2006 who both reported 61.29% of isolated *S. aureus* strains being resistant to oxacillin. Also, Khatoon *et al.,* 2010 reported 40% isolated *S. aureus* strains being resistant to oxacillin. Also, Soltani et al. (2010) reported 62% of isolated *S. aureus* to be resistant to oxacillin. This high resistance of *S. aureus* to oxacillin is in contrast to work done by Alborzi *et al.* (2000) who reported 33% of *S. aureus* to be resistant to oxacillin. Furthermore, in Nigeria, Ikeagwu *et al.* (2008) reported 87% of resistance to cloxacillin among isolated *S. aureus* strains in hospitals. This shows that there is overall increase in resistant to oxacillin worldwide as is evident from many surveillance studies (Flunt *et al.,* 2001). The organism's increasing rate of resistance to these agents might be due to the uncontrollable availability of the agents in sub-therapeutic quantity at every drug vendor in this environment which usually leads to their frequent and indiscriminate use in infections (Okeke *et al.,* 1999 and Akinduti *et al*., 2021). Hence, the use of these agents in the empiric treatment of urinary tract infections is useless and should be discouraged (Onanuga and Awhowho, 2012). This study observed low resistance of *S. aureus* in hospital to gentamicin (36.6%), cefuroxine (45.6%), ceftriaxone (35.2%), ciprofloxacin (20.9%), streptomycin (39.7%), cotrimoxazole (12.7%) and erythromycin (31%). This finding is in consistent with the work of Akortha and Ibadin, (2008) who reported 49.8% resistance of *S. aureus* to gentamicin. This observed variation in the pattern of the organism's resistance might be attributed to the changing nature of the pathogen in the different environmental conditions of the study area (Astal *et al*., 2002). In the present study, it was observed that *S. aureus* isolated from communities screened were resistant to oxacillin (53.3%), penicillin G (63.3%), pefloxacin (58%), ampicillin/cloxacin (56.7%), cefuroxine (61.3%) and ceftriaxone (75.3%). The high resistance of *S. aureus* (63.3%) to penicillin G in communities screened is in line with the work of Soltani *et al*. (2010) who reported 96% of *S. aureus* being resistant to penicillin G. This result is also in consistent with many reported research works (Alborzi *et al.,* 2000; Goff and Dowzicky, 2007).

From this result, it was observed that *S. aureus* isolated from communities was resistant to many antibiotics. This is in agreement with the work of some researchers who reported that resistant strains of *S. aureus* are increasingly found in the community even among individuals who have never been hospitalized (Ezeonu and Ayogu, 2013). This study also showed low resistance of *S. aureus* to Gentamycin (40%), amoxicillin (30%), ciprofloxacin (20%), streptomycin (35.3%), cotrimoxazole (26.7%) and erythromycin (42.7%). This observed low resistance of *S. aureus* to these commonly used antibiotics is because; these antibiotics are inexpensive and readily available. Strains of CA-MRSA are more frequently susceptible to a variety of non-beta-lactam antibiotics that is typically less resistance to non-beta-lactam antimicrobial agents (Maha *et al*., 2009). In the present study, MRSA strains from communities were less resistance to erythromycin (46.5%), ciprofloxacin (31.4%), gentamicin (41.9%) and cotrimazole (14.0%). This study is in line with a study that has been mirrored elsewhere (Albrich and Harbarth, 2008; File, 2007). This shows that these antibiotics are most effective agents against isolated MRSA strains and since they are inexpensive and available antibiotic in this area and because of its broad spectrum of activity, they are prescribed for different infections. This result is in line with Farzana and Hameed, 2006 who reported a susceptibility rate of MRSA (42%) to gentamicin. Currently these antibiotics are used as combination therapy with other effective antibiotics for synergistic effects and for prevention of resistance in the treatment of gram-positive related infections (Soltani *et al*., 2010). Also, Khatoon *et al*., 2010 reported a susceptibility rate of MRSA (24%) to gentamicin. The low resistance of CA-MRSA to these antibiotics is in line with the work of Ibe *et al*. (2013) who reported that CA-MRSA isolates showed less resistance to erythromycin (19.6%), ceftriaxone (17.6%), gentamycin (13.7%) and ciprofloxacin (11.8%). The low resistance (41.9%) reported in gentamicin in this study could be due to the absence of the plamid puB10 ecoding resistance for aminoglycoside (gentamicin) in the isolates (Ibe *et al*., 2013). This result is closely related to the reports of Al-Mohana *et al*. (2012) who reported 27% resistance to gentamicin but in contrast with the work of Khadri and Alzohairy (2010) and Perwaiz *et al*. (2007) who reported 65% and 93% resistance to gentamicin in isolates of MRSA respectively. Ciprofloxacin with the resistance rate of (31.4%) in this study supports previous work which proposed that it should be used as an alternative therapy for MRSA infections (Pai *et al*., 2013). However, the result contradicts the reports of Gupta *et al*. (2013) who reported ciprofloxacin to be ineffective (with resistance rate of 99%) against MRSA and Tenguria *et al*. (2013) who reported 83% resistance to ciprofloxacin in a study conducted in India.

The continuous increase of HA-MRSA resistance to wide range of antibiotics is of great concern for our healthcare system. However, good hospital infection control policies may be a good barrier for these infections. HA-MRSA was observed to have less resistance to ceftriaxone (36.4%), ciprofloxacin (42.1%), streptomycin (37.3%), gentamicin (46.9%) and erythromycin (31.1%). This is in consistent with the work of Goyal *et al*. (2013) who reported HA-MRSA to have less resistant to gentamicin (48.77%), ciprofloxacin (41.95%), erythromycin (20.25%). The reason for lesser resistance in our HA-MRSA isolates may be due to the difference in antibiotic prescription in various hospitals. In the current study 64.4% of the MRSA isolated were multidrug resistance. The high level of multiple drug resistance shown by the MRSA isolates is of great public health significance. All the MRSA isolates showed resistance to at least four antibiotics tested in this study, indicating the presence of strong selective pressure from antibiotics use in the hospital and community settings as well as a result of widespread person – to – person transmission of multidrug resistant isolates (Ayliffe, 1997). Majumder *et al*., (2001) from Assam, Anupurba *et al*., (2003) from Ultarpradesh and Vidhani et al., (2001) from Delhi in India reported high percentage of multidrug MRSA but from high-risk patients admitted in burns and orthopedic units. About 13.6% of the MRSA isolates were resistant to 4 antibiotics, 12% were resistant to 5 antibiotics, 13.6% were resistant to 6 antibiotics, 5.1% were resistant to 7 antibiotics, 10.2% were resistant to 8 antibiotics, and 6.8% were resistant to 9 antibiotics used. None of the isolates was fully sensitive to all antibiotics tested. This result is in agreement with that of Okwu *et al*. (2012) who reported 46.2% of MRSA to be resistant to 6 antibiotics, 23.1% to be resistant to 7 antibiotics, 23% to be resistant to 5 and 7.7% to 8 antibiotics. This result is also in agreement with that of Ibe *et al*. (2013) who reported 60% of the MRSA isolates were resistant to 4 and 6 antibiotics, 20% were resistant to 5 and 7 and 20% were resistant to 8 antibiotics used. The emergence of multidrug resistant bacteria is attributed to inappropriate prescription, self-medication and indiscriminate use of antibiotics. In this study, a high degree of antibiotic resistance was observed, with most of the MRSA isolates exhibiting resistance to at least one antibiotic and 190 isolates (64.4%) exhibiting resistance to four or more antibiotics. None of the isolates exhibited 100% susceptibility to the antibiotics tested. Furthermore, both the hospital and community isolates exhibited high degree of resistance to the other classes of antibiotics even though resistance of the hospital isolates was slightly higher. The results, therefore, raise the question of whether the community strains were transmitted by discharged patients and health care workers as has been suggested previously (Layton *et al*., 1995; Cookson, 2000), or whether they arose by some other mechanism. Whatever the mechanism, however, these findings are consistent with a previous study conducted in the same geographical zone in which the use of plasmid profiling suggested homogeneity between hospital and community isolates of *S. aureus* (Ezeonu and Ayogu, 2013). The study had suggested that in an environment such as the Nigerian environment, where antibiotics are easily obtained without prescription and where there is a wide practice of self-medication, antibiotics are used in the community just as they are used in the hospitals, hence eliminating the delineation of strains due to selection pressure in the two different environments. Indeed, the findings in this study tend to agree with the suggestion that hospital-community interactions in human populations could foster co-existence between hospital-acquired and community-acquired MRSA (Kouyos *et al*., 2013); given that in the Nigerian environment, there is free movement of both patients and personnel between the hospital community and HA-MRSA may easily move into the community and vice versa. The antibiotic resistance patterns of isolates in this study suggest that it is the HA-MRSA phenotype that is prevalent in both hospital and community environments in Nsukka.

5. Conflict of Interest Statement

Authors declare that they have no conflict of interest

6. References

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