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Prevalence and Antimicrobial Susceptibility of Methicillin Resistant Staphylococcus aureus and Coagulase-Negative Staphylococci Isolated from Apparently Healthy University Students in Ota, Nigeria

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Abstract
In Nigeria, high prevalence of methicillin resistant *Staphylococcus aureus* (MRSA) in clinical samples and healthy individuals is increasingly being reported. However, very little is known regarding coagulase negative Staphylococci (CoNS) strains isolated from healthy individuals, especially, given their increasing recognition as agents of clinically significant infections and as reservoirs of antimicrobial resistance determinants. Therefore, this study was undertaken, to establish the prevalence of MRSA, and to characterize the antimicrobial susceptibility of CoNS strains from apparently healthy University student volunteers in Ota, Ogun State, Nigeria. A better characterization of CoNS strains in their commensal lifestyle could give us new insights on their pathogenic potential. A total of 100 (nose and neck swabs) samples were collected from healthy students and screened using standard microbiological techniques. *Staphylococcus* species isolated on the basis of growth on mannitol salt agar were further characterized based on biochemical tests and novobiocin resistance. Commercially prepared antibiotics discs were used to test the susceptibility of the *Staphylococcus* isolates obtained. Data generated were analyzed descriptively and expressed in percentages. A total of 39 *Staphylococcus* species were identified as *S. aureus* (17), *S. saprophyticus* (8), *S. epidermidis* (7), *S. hemolyticus* (5) and *S. hominis* (2). The *S. aureus* strains were highly resistant (>94%) to methicillin (oxacillin / cloxacillin) and several non-β-lactams including clindamycin (100%), co-trimoxazole (82.4%), and vancomycin (82.4%). The incidence of methicillin resistance among CoNS was 77.3% with moderate resistance to co-trimoxazole (63.6%), clindamycin (40.9%), gentamicin (36.36%) and vancomycin (31.8%). This study has demonstrated high prevalence of MRSA and MRCoNS isolates from apparently healthy University student volunteers in Ota, Nigeria, and underlines the need for periodic surveillance studies of this type, reassessment of policies on antibiotics use within and outside the University environments, development and enforcement of measures to prevent the spread of MRSA and MRCoNS infections in the community.
Keywords: Coagulase-Negative *Staphylococcus* species (CoNS), Community-associated methicillin resistant *Staphylococcus aureus* (CA-MRSA), Multi-drug resistance, Nigeria, Susceptibility

1. Introduction

The *Staphylococcus*, consisting of 45 species, is a genus of Gram-positive cocci in grape-like clusters that are non-motile and catalase positive with ability to grow in a variety of conditions—aerobically, and anaerobically, in the presence of a high concentration of salt and at temperatures ranging from 18°C to 40°C (Ryan and Ray, 2004; Murray *et al.,* 2009). *Staphylococcus aureus* has the ability to coagulate blood using the coagulase enzyme and on the basis of this can be distinguished from most other coagulase-negative staphylococcal species (CoNS) such as *S. epidermidis, S. saprophyticus*, *S. haemolyticus*, *S. hominis* and *S. lugdunensis* (Ieven *et al*., 1995). Staphylococci are ubiquitous. All persons have coagulase-negative staphylococci on their skin, and transient colonization of moist skin folds with *S. aureus* is common (Murray *et al*., 2009).

S. aureus is widely considered a major factor of nosocomial infections ranging from minor skin infections, osteomyelitis and endocarditis, to more serious infections including fatal necrotizing pneumonia (Archer, 1998). Although these infections were historically treatable, beginning in the 1980s, methicillin-resistant *S. aureus* (MRSA) strains have spread rapidly in susceptible hospitalized patients, dramatically changing the therapy available for preventing and treating staphylococcal infections (Enright *et al*., 2002). Although MRSA infections were relatively uncommon among healthy individuals in the community, a dramatic change was observed in 2003 when new strains of MRSA were reported to be responsible for outbreaks of community-acquired cutaneous infections and severe pneumonia (Marcinak and Frank, 2003). MRSA infections present a challenge to infection control and treatment strategies, resulting in increased morbidity, mortality, and length of hospitalization and health care costs (Macedo-Viñas *et al*., 2013; Kim *et al*., 2001; Kim *et al*., 2014).

Although, CoNS were historically considered harmless with relatively low virulence (Kloos and Banerman, 1994; von Eiff *et al*., 2001), they are increasingly recognized as agents of clinically significant

infections of the bloodstream and other sites. Data from a previous United States National Nosocomial Infections Surveillance System report showed that CoNS were the most commonly reported pathogens (37.3% for CoNS versus 12.6% for *S. aureus*) isolated from bloodstream infections in intensive care unit patients (Richards *et al*., 1999). The CoNS have been implicated as the causative agents in urinary tract disease, pneumonia, endophthalmitis, (Younger *et al*., 1987), surgical wound infections, breast abscess (Moazzez, 2007), osteomyelitis, native valve endocarditis (Marculescu *et al*., 2006), periodontitis, chronic rhinosinusitis, and otitis media (Post *et al*., 2004). Of particular note, is the propensity of some CoNS to form a protective biofilm which interferes with phagocytosis and efficacy of antimicrobial peptides (Otto, 2008; Fredheim *et al*., 2009; Oliveira and Cerca, 2013). More importantly, CoNS often serve as reservoirs of antimicrobial resistance determinants; resistance to penicillin approaches 90 to 95 percent, while resistance to methicillin and semisynthetic penicillins has been observed in more than 80 percent of CoNS isolates (Diekema *et al*., 2001), they are also often resistant to multiple classes of antibiotics in addition to β-lactams. Patients at particular risk for CoNS infections include those with prosthetic devices, pacemakers, intravascular catheters, and immunocompromised status (Murray *et al.,* 2009).

In Africa, MRSA prevalence varies with different countries, high in some and low in others (Falagas *et al*., 2013). In Nigeria, the prevalence of hospital associated-MRSA in clinical samples also varies from one area to another; 43% in Jos (Taiwo *et al*., 2004), 34.7% in Ilorin (Ikeh, 2003), 30.4% in Ibadan (Adetayo *et al*., 2014), 28.6% in Kano (Nwakwo, 2010) and 12.5% in Maiduguri (Okon *et al*., 2011). Reports of studies on prevalence of community-associated MRSA (CA-MRSA) are also emerging in Nigeria; 10.8% in apparently healthy school children in Okada, Edo State (Okwu *et al*., 2012), 41% in apparently healthy University students in Ekpoma, also of Edo State (Eke *et al*., 2012), 60.7% in otherwise healthy inhabitants of Uturu communities in Abia State (Ibe *et al*., 2013), 71.7% in healthy women volunteers in the Abuja Capital Territory (Onanuga *et al*., 2005). However, despite the increasing recognition of CoNS as agents of clinically significant infection and their resistance to multiple classes of antibiotics in addition to beta-lactams, very little is known in Nigeria regarding CoNS strains isolated from healthy individuals in the community. This study was undertaken, to establish the prevalence of MRSA, and to characterize the antimicrobial susceptibility of CoNS strains from the skin (neck) and nose of apparently healthy University student volunteers in Ota, Ogun State of Nigeria. The antimicrobial susceptibility profile of the staphylococcal isolates may inform about possible sources of antimicrobial resistance in the community. The sensitivity of the isolates to selected antimicrobials may guide clinical treatment decisions. A surveillance study of this type in the community may highlight the need for reassessment of policies on antibiotics use within and outside the University environments, and development of measures to prevent the spread of MRSA and MRCoNS infections in the community.

2. Materials and Methods

Study area: This study was carried out in Ota, Ado/Ota Local Government Area of Ogun State, Nigeria.

Subjects: A total of 100 apparently healthy students of Covenant University, Ota (50 males; 50 females) served as the study population. The participants were asked to complete a questionnaire regarding gender, hospitalization history, antibiotic use, and contact with medical staff in the preceding six months.

Ethical Approval: All the participants in this study gave written informed consent following exchange of information about the study background and procedures with preservation of their autonomy, privacy, and confidentiality. The study was approved by the Research Ethics Committee of the Department of Biological Sciences, Covenant University, Ota, Ogun State of Nigeria.

Study Duration: This study was carried out within a period of three months.

Sample Collection and Media: A total of 100 swab samples (50 nose and 50 neck) were collected from apparently healthy male and female Covenant University student volunteers (male- 25 nose and 25 neck, female- 25 nose and 25 neck). All samples were collected using swab stick soaked in sterile saline, labelled, packaged and transported immediately to the laboratory for microbiological studies. The media used for this study include the following: Nutrient broth (Oxoid), Nutrient agar (Biomark), Mannitol salt agar (Biomark), Blood agar (Biomark), and Mueller Hinton agar (Oxoid). All microbiological media were prepared following manufacturers' instructions.

Identification and characterization of bacterial isolates: The nose and neck swab specimens were inoculated on Mannitol salt agar (MSA). The culture plates were incubated at 35^0C for 48 hours under aerobic conditions following which they were examined, and the appearance, colour, size and morphology of the colonies were recorded. The Gram stain reaction was carried out on the bacterial isolates and they were further characterised to species level based on the results obtained from a series of biochemical tests including catalase production, coagulase activity, blood agar hemolysis and novobiocin (5µg) susceptibility assay (Ryan and Ray, 2004). The bacterial isolates were further sub-cultured on agar slants and incubated at 35^0C for 24 hours, following which they were stored at 4^0C.

Determination of Antimicrobial Susceptibility Pattern: The bacterial isolates were tested for susceptibility to 13

different antimicrobial agents by the disc diffusion method on Mueller Hinton agar (Bauer *et al*., 1966). The antimicrobial agents tested were: augmentin, 30µg (AUG), amoxicillin, 25µg (AMX), erythromycin, 15µg (ERY), tetracycline, 30µg (TET), cloxacillin, 5µg (CXC), gentamicin, 10µg (GEN), co-trimoxazole, 25µg (COT), chloramphenicol, 25µg (CHL), oxacillin, 5µg (OX), novobiocin, 5µg (NV), clindamycin, 0.5µg (DA), vancomycin, 5µg (VA) and penicillin, 10µg (P). The antibiotics discs were placed on Mueller Hinton agar plates previously seeded with 0.5ml of inoculum (1.5 x 10^8 colony forming unit) of isolates. The plates were incubated at 35^0C for 24 hours and observed for zones of inhibition, determined by measurement using a ruler and recorded. Each isolate was tested in two independent occasions in triplicate. Zone size less than 12 mm was considered resistant and zone size greater or equal to 16 mm was considered sensitive. Multiple antibiotic resistance was defined as resistance to three or more classes of antimicrobial agents.

Statistical Analysis: Data generated were analysed descriptively and expressed in percentages.

3. Results

Isolation and Identification of *Staphylococcus* species

The student volunteers denied visiting the Covenant University Healthcare centre or any hospital in the six months prior to enlistment for this study. Similarly, they reported not taken any antibiotics medication during the prior six months nor did they have any skin abrasion or open wound prior to and during the sampling period. Following cultivation of sample swab streaks from the apparently healthy University students on MSA plates for 48 hours, growth was seen on 39 out of 100 plates. The results showed that of the 50 nose swabs examined, 24 samples yielded positive for *Staphylococcus* species and also, of 50 samples of neck swabs examined, 15 yielded positive for *Staphylococcus* species as seen in Table I. The number of *S. aureus* isolated from nose was 10 (41.7%) and from neck was 7 (47%) as shown in Table I. Among the *Staphylococcus* species isolated, the prevalence of *S. aureus* was higher; the species distribution of the analysed strains was as follows: *S. aureus*- 17 strains (43.6%), *S. saprophyticus*- 8 strains (20.5%), *S. epidermidis*- 7 strains (17.9%), *S. hemolyticus*- 5 strains (12.8%), and *S. hominis*- 2 strains (5%) as seen in Table I.

TABLE I: Identification of *Staphylococcus* species isolated from healthy University students

Source	Species	No. of Isolates	Frequency (%)
Nose	*S. aureus*	10	41.7
	S. epidermidis	6	25
	S. saprophyticus	4	16.7
	S. hemolyticus	3	12.5
	S. hominis	1	4.2
Neck	*S. aureus*	7	46.7
	S. epidermidis	1	6.7
	S. saprophyticus	4	26.7
	S. hemolyticus	2	13.3
	S. hominis	1	6.7

Antimicrobial Susceptibility of *Staphylococcus* species

The *Staphylococcus* species isolated from apparently healthy University students examined in this study demonstrated resistance to tested antibiotics (Table II a, b and c).

S. aureus strains were highly resistant to oxacillin (100%), clindamycin (100%), amoxicillin (94.1%), cloxacillin (94.1%), co-trimoxazole (82.4%), penicillin (82.4%), vancomycin (82.4%), and augmentin (76.5%), and moderately resistant to erythromycin (58.8%), gentamicin (58.8%), chloramphenicol (58.8%) and tetracycline (47.1%).

S. saprophyticus strains were highly resistant to oxacillin (87.5%), penicillin (87.5%), and clindamycin (75%), moderately resistant to co-trimoxazole (62.5%), vancomycin (62.5%), and cloxacillin (62.5%), while highly sensitive to gentamicin (12.5%), chloramphenicol (12.5%), and tetracycline (12.5%), and moderately sensitive to erythromycin (25%), augmentin (37.5%), and amoxicillin (37.5%).

S. epidermidis strains were highly resistant to co-trimoxazole (85.7%), oxacillin (71.4). amoxicillin (71.4%), cloxacillin (71.4%), augmentin (71.4%), moderately resistant to gentamicin (57.1%) while sensitive to tetracycline (42.9%), penicillin (42.9%), erythromycin (28.6%), chloramphenicol (14.3%), clindamycin (14.3%) and very sensitive to novobiocin (0%), vancomycin (0%).

S. hemolyticus strains were highly resistant to oxacillin (80%), coxacillin (80%), amoxicillin (80%), and augmentin (80%), moderately resistant to penicillin (60%), co-trimoxazole (60%), and gentamicin (60%) while sensitive to erythromycin (20%), tetracycline (20%), vancomycin (20%) and very sensitive to novobiocin (0%), chloramphenicol (0%).

The *S. hominis* strains demonstrated high sensitivity to eight of the 13 antibiotics tested.

Table II a: The number/percentage (%) of *Staphylococcus* species **resistant** to selected antibiotics

Species (No. of strains)	AUG	AMX	ERY	TET
S. aureus (17)	13/76.5	16/94.1	10/58.8	8/47.1
S. saprophyticus (8)	3/37.5	3/37.5	2/25	1/12.5
S. epidermidis (7)	5/71.4	5/71.4	2/28.6	3/42.9
S. hemolyticus (5)	4/80	4/80	1/20	1/20
S. hominis (2)	0/0	1/50	0/0	0/0

AUG- Augmentin, AMX- Amoxicillin, ERY- Erythromycin, and TET- Tetracyline

Table II b: The number/percentage (%) of *Staphylococcus* species **resistant** to selected antibiotics

Species (No. of strains)	CXC	GEN	COT	CHL
S. aureus (17)	16/94.1	10/58.8	14/82.4	10/58.8
S. saprophyticus (8)	5/62.5	1/12.5	5/62.5	1/12.5
S. epidermidis (7)	5/71.4	4/57.1	6/85.7	1/14.3
S. hemolyticus (5)	4/80	3/60	3/60	0/0
S. hominis (2)	1/50	0/0	0/0	0/0

CXC- Cloxacillin, GEN- Gentamycin, COT- Cotrimoxazole and CHL- Chloramphenicol

Table II c: The number/percentage (%) of *Staphylococcus* species **resistant** to selected antibiotics

Species (No of Strains)	OX	NV	DA	VA	P
S. aureus (17)	17/100	0/0	17/100	14/82.4	14/82.4
S. saprophyticus (8)	7/87.5	8/100	6/75	5/62.5	7/87.5
S. epidermidis(7)	5/71.4	0/0	1/14.3	0/0	3/42.9
S. hemolyticus (5)	4/80	0/0	2/40	1/20	3/60
S. hominis (2)	1/50	0/0	0/0	1/50	1/50

OX- Oxacillin, NV- Novobiocin, DA- Clindamycin, VA- Vancomycin and P- Penicillin.

Strains of *Staphylococcus* species isolated from healthy University student volunteers were highly sensitive to chloramphenicol (69.2% -sensitive strains), tetracycline (66.7% -sensitive strains), and erythromycin (61.5% -sensitive strains) while oxacillin (87.2% -resistant strains), cloxacillin (79.5% -resistant strains), amoxicillin (74.4% -resistant strains), co-trimoxazole (71.8% - resistant strains), penicillin (69.2% -resistant strains), augmentin (64.1% -resistant strains) and vancomycin (51.3% -resistant strains) showed low anti-Staphylococcal activity (Fig. 1).

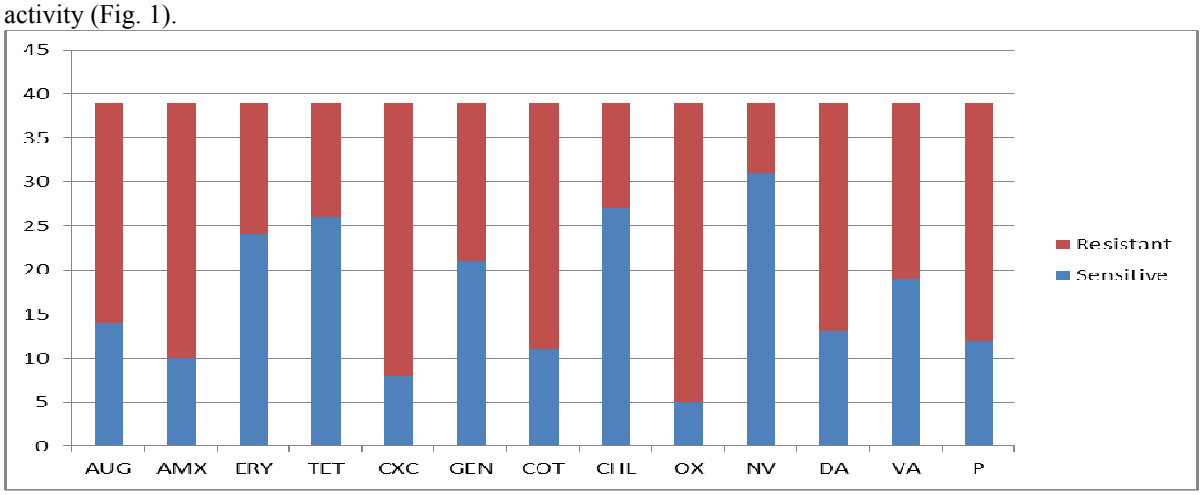

Fig 1: The proportion of sensitive and resistant *Staphylococcus* species to the tested antibiotics.

AUG- Augmentin, AMX- Amoxicillin, ERY- Erythromycin, TET- Tetracyline, CXC- Cloxacillin, GEN- Gentamycin, COT- Cotrimoxazole, CHL- Chloramphenicol, OX- Oxacillin, NV- Novobiocin, DA- Clindamycin, VA- Vancomycin, and P- Penicillin.

The susceptibility profile for all CoNS strains isolated and characterized in this study demonstrated that they were also highly sensitive to chloramphenicol (80% -sensitive strains), erythromycin (68% -sensitive strains) and tetracycline (68% -sensitive strains) while oxacillin (77.2% -resistant strains), penicillin (63.64% -resistant strains), cloxacillin (68.2% -resistant strains), co-trimoxazole (63.6% -resistant strains), clindamycin (40.9 – resistant strains), gentamicin (36.36% resistant strains) and vancomycin (31.8% -resistant strains) showed moderate to high resistance (Fig. 2).

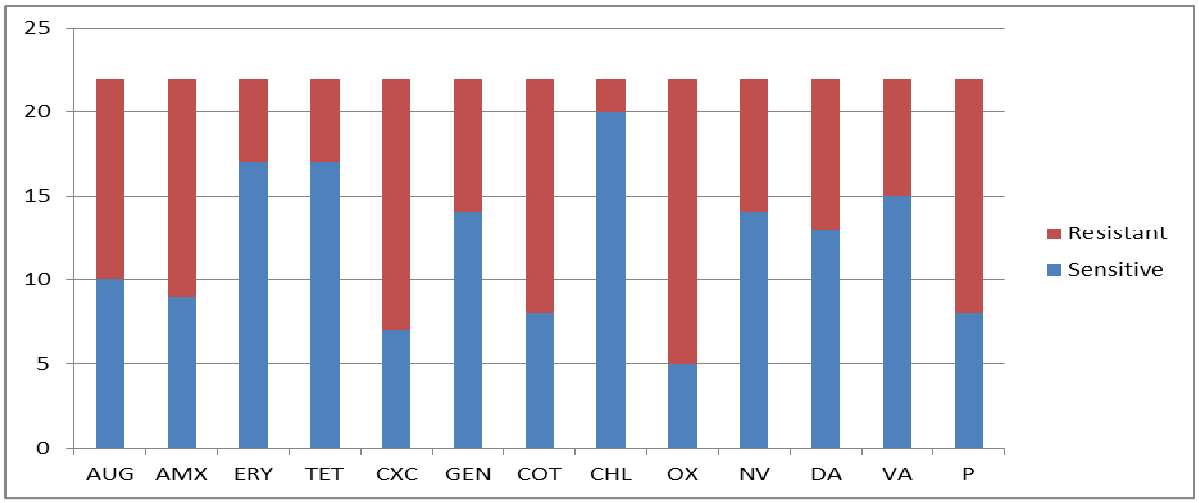

Fig 2: The proportion of sensitive and resistant CoNS strains to the tested antibiotics
AUG- Augmentin, AMX- Amoxicillin, ERY- Erythromycin, TET- Tetracyline, CXC- Cloxacillin, GEN- Gentamycin, COT- Cotrimoxazole, CHL- Chloramphenicol, OX- Oxacillin, NV- Novobiocin, DA- Clindamycin, VA- Vancomycin, and P- Penicillin.

4. Discussion

S. aureus, widely considered a major factor of nosocomial infections (Archer, 1998), increasingly resistant to methicillin (Enright *et al*., 2002) and other classes of antimicrobial agents is also responsible for outbreaks of community-acquired infections (Marcinak and Frank, 2003). CoNS, historically considered harmless with relatively low virulence (Kloos and Banerman, 1994; von Eiff *et al*., 2001), are increasingly recognized as agents of clinically significant infection of the bloodstream and other sites, and they often serve as reservoirs of antimicrobial resistance determinants. In this study, an overall prevalence of 43.6% of *S. aureus* compared to 56.4% of CoNS was obtained from apparently healthy University students. This is in line with the study by Finney *et al.*, (2013) who reported prevalence of 50% for *S. aureus* and 50% for CoNS among normal healthy student and staff volunteers from Ajman in the United Arab Emirates. The study by Kejela and Bacha (2013) also showed the overall frequency of isolation of *S. aureus* of 47.74% and that of CoNS of 52.26% from healthy primary school children and prisoners in Ethiopia. However, the observed prevalence of *S. aureus* in this study is higher than previously reported in a student community in the United States where 29% of the volunteers carried *S. aureus* (Bischoff *et al*., 2004). Differences in ethnicity and socio-economic status of individuals demonstrated through differences in living conditions, including access to and use of washing and sanitation facilities and differing health seeking behaviour may account for the regional differences in prevalence of *S. aureus* (Tong *et al*., 2012).

It is very alarming that almost all the *S. aureus* strains (94-100%) isolated from the apparently healthy students in this study were highly resistant to methicillin (oxacillin/ cloxacillin). The results also show that the *S. aureus* isolates have high resistance to amoxicillin (94.1%) and penicillin (82.4%), which support earlier findings, that MRSA strains are equally resistant to all β-lactam antibiotics (Onanuga *et a*l., 2005) which may be due to *mec*A, which is carried by a unique mobile genetic element, staphylococcal cassette chromosome *mec* (SCC*mec*) integrated into the *S. aureus* chromosome (Hiramatsu *et al*., 2002). The MRSA prevalence in this study represents more than double the rate previously reported in apparently healthy University students in Edo State of Nigeria (Eke *et al*., 2012), but comparable to the findings of Onanuga *et al*. (2005) which demonstrated that 71.7% of *S. aureus* isolated from the community were methicillin resistant. Other risk factors associated with MRSA colonization in the participants that cannot be ruled out in this study include living conditions in the University hostels, repeated exposure to antibiotics (at least a year prior to participation in the study), skin-to-skin contact, sharing of University athletic equipment or sharing of personal items such as bar soap and towels (Weber, 2005).

Moreover, the characterization of the MRSA isolates in this study also revealed that they have developed resistance to several non-β-lactam antibiotics tested; greater than 75% resistance to clindamycin (lincosamides), co-trimoxazole (folate pathway inhibitors), and vancomycin (glycopeptides). This finding is consistent with the multi-drug resistant profiles of MRSA isolates reported by Olayinka *et al*. (2005) who observed 57.7% vancomycin resistant *S. aureus*, Onanuga *et al*., (2005) who showed a high resistance to clindamycin (92%) and vancomycin (89%), Kumurya (2015) who showed 87.12 % methicillin resistant isolates with *in vitro* inducible clindamycin resistance, and the study by Shittu *et al*., (2012) in which 82.3% of *S. aureus* were resistant to co-trimoxazole. However, our results are contrary to the findings of Patel *et al.*, 2006, Wylie

and Nowicki (2005), Mandelia and Shenoy (2010) who reported 80-100% MRSA susceptibility to vancomycin, clindamycin and co-trimoxazole.

The CoNS isolates are one of the most important agents of nosocomial bacteremia, worldwide, which is complicated by the high level of methicillin resistance frequently observed among them (Diekema *et al*., 2001, NNIS System, 2004). In this study, the incidence of methicillin-resistance among CoNS isolates from the apparently healthy University students was 77.3%. The MRCoNS also demonstrated moderate resistance to non-β-lactam antibiotics; co-trimoxazole (63.6%), clindamycin (40.9%), gentamycin (36.36%) and vancomycin (31.8%). These findings are consistent with the studies by Cuevas *et al*., (2004) who observed MRCoNS prevalence of 61.3% and resistance to gentamicin (27.8%) in Spain, and Ma *et al*., (2011) who reported MRCoNS prevalence of 79.1% and multiple resistance to clindamycin (53.7%), co-trimoxazole (58.5%) and gentamicin (28%) in China. The existence of MRCoNS strains susceptible to chloramphenicol (80% -sensitive strains) provides an opportunity for the recommendation to use this drug for empirical treatment of MRCoNS infections in this study population (Daniyan and Sani, 2011, Shanmuganathan *et al.,* 2005).

Nigeria is a country with high population density, where the indiscriminate use of common antibiotics in humans without prescriptions is extremely high coupled with significant abuse arising from self-medication which is often associated with inadequate dosage and failure to comply with treatment (Yah *et al*., 2008), and there is no regulation of the use of antibiotics in livestock and poultry (Olatoye, 2011). This combination of factors makes a perfect scenario for the spread of drug-resistant bacteria in the community (Yah *et al*., 2008; Olatoye, 2011). The high level resistance could be associated with earlier exposure of these drugs to isolates which may have enhanced development of resistance. However, since none of the participants in this study had received vancomycin because the drug is not available for clinical use in Nigeria (Yah et al., 2008), it is difficult to understand the drug selection pressure and the mechanism responsible for decreased susceptibility to vancomycin in these isolates. There is a possibility, however, that some of the isolates may be carrying the vanA operon from transposon Tn1546, acquired from vancomycin-resistant *Enterococcus faecalis*, which is known to alter cell wall structure and metabolism, but the resistance mechanisms are less well defined (Pe´richon and Courvalin, 2009).

The high level of multiple drug resistance shown by the MRSA and MRCoNS isolates from apparently healthy student volunteers in this study is of serious concern. There is an urgent need to adopt basic principles of asepsis and high personal hygiene, for most staphylococcal infections are readily transmitted among susceptible populations by the individuals who have acquired them. We also know that the misuse of antibiotics in both hospital and community settings can cause MRSA and MRCoNS to become more virulent and more difficult to contain and treat. If antibiotics are prescribed to treat infections unnecessarily or when individuals do not complete their prescriptions, infections can develop a resistance to antibiotics.

Our work has some limitations that should be mentioned. First, study participants were selected on the basis of a questionnaire including items on contact with the Covenant University Healthcare centre or any local hospital staff, or usage of antibiotics during the prior six months or presence of any skin abrasion or open wound prior to and during the sampling period. We cannot exclude the possibility that some study participants had experienced earlier hospitalization (in the prior year), the impact of living conditions in the University hostels, skin-to-skin contact, sharing of University athletic equipment or sharing of personal items such as bar soap and towels (Weber, 2005). Reliable retrospective data on antibiotic use during the months before inclusion were unavailable. The study involved only a small number of isolates, and the molecular characterization of MRSA and MR-CoNS isolates has yet to be conducted. It is well established that bacteria exhibiting a biofilm phenotype are recalcitrant to antimicrobial therapy (Otto, 2008; Fredheim *et al*., 2009; Oliveira and Cerca, 2013). Studies are underway to determine the biofilm formation ability of CoNS stains isolated in this study and to assess whether their antimicrobial resistance can be intimately related to their biofilm formation ability.

5. Conclusion

This study has demonstrated high prevalence of MRSA and MRCoNS from apparently healthy student volunteers in Ota, Nigeria. It has also demonstrated significant resistance of these strains, especially against non-β-lactam antibiotics such as clindamycin and co-trimoxazole (both commonly used), and vancomycin that is used in severe cases of MRSA and MRCoNS infections in the Western world, but not yet available and prescribed in Nigeria. This study underlines the need for periodic surveillance studies of this type, reassessment of policies on antibiotics use within and outside the University environments, development and enforcement of measures to prevent the spread of MRSA and MRCoNS infections in the community including proper care of wounds, frequent washing of hands and avoidance of sharing personal items.

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