ACADEMIC JOURNALS
expand your knowledge

Journal of Microbiology and Antimicrobials

Full Length Research Paper

Prevalence, susceptibility testing and multi drug resistance risk factors to methicillin resistant *Staphylococcus aureus* in nasal carriage of hospitalized patients and medical staff in selected hospitals in Cameroon

Leontine Kouemou Sinda[1,4]*, Jerome Nyhalah Dinga[2], Samuel Wanji[1] and Sinata Shiro Koulla[3,5]

[1]Department of Microbiology and Parasitology, Faculty of Science, University of Buea Cameroon.
[2]Biotechnology Unit, Department of Biochemistry and Molecular Biology, Faculty of Science, University of Buea, Cameroon.
[3]Department of Biomedical Sciences, Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, Cameroon.
[4]Saint Leonard Health and Research Foundation, Limbe, Cameroon.
[5]Division of Operational Research, Ministry of Public Health, Cameroon.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major hospital acquired pathogen. In Cameroon, there is limited data on nasal carriage of MRSA and its antibiotic susceptibility testing and risk factors for multi resistance to antibiotics in hospitalized patients and medical staff . A prospective, qualitative, cross-sectional hospital-based study was carried out. Anterior nasal swabs were taken from 579 participants and bacterial strains were identified by conventional method and antibiotic susceptibility testing. Methicillin resistance was confirmed with cefoxitin and oxacillin disks. Of the 579 samples analysed, 53.0% were positive for *S. aureus*, 45.4% were MRSA. MRSA constituted 85.7% of all the *S. aureus* identified. The prevalence of MRSA in nasal carriage was significantly higher in females (49.6%) than in males (34.0%). The overall prevalence of MRSA in nasal carriage in both medical staff and hospitalized patients was 45.4%. The prevalence of MRSA in nasal carriage was significantly higher in RHL (49.0%) and RHB (48.5%) compared to the UTHY (36.3%). The prevalence of MRSA in nasal carriage was significantly higher in the surgical ward (59.7%) and paediatric ward (45.2%) compared to the other units. Among the MRSA isolates, the maximum sensitivity was observed with vancomycin (97.0%) and minocycline (95.1%), while the least sensitivity was observed with penicillin (0.0%) and ampicillin (0.8%). Binary logistic regression model showed that being aged 35 years an above and being hospitalized for more than 15 days were strongly associated with MDR to MRSA. Nasal carriage of MRSA is increasing rapidly and call for urgent preventive measures.

Key words: Healthcare personnel, adult patients, nasal carriage, antibiotic susceptibility, risk factors, health care personnel, adult, patients, multi drug resistance (MDR), methicillin-resistant *Staphylococcus aureus* (MRSA).

INTRODUCTION

Methicillin-resistant *Staphylococcus aureus* (MRSA) is any strain of *S. aureus* bacteria that has developed resistance to beta-lactam antibiotics which include the penicillins (methicillin, dicloxacillin, nafcillin, oxacillin.) and the cephalosporins. This results in infections that are more difficult to treat than ordinary Staphylococcal infections. MRSA is a bacterium responsible for several difficult-to-treat infections in humans. It may also be called multidrug-resistant *S. aureus* or oxacillin-resistant *S. aureus* (ORSA). MRSA is a real burden in hospitals where patients with open wounds, invasive devices and weakened immune systems are at greater risk of infection than the general public. MRSA is a growing problem in shared facilities such as hospitals, healthcare facilities and nursing homes.

MRSA has during the last three decades evolved as a major health care-acquired pathogen worldwide; it now accounts for up to 40% of staphylococcal bacteraemia in developed countries. (Boon et al., 2008). However, there are considerable differences between various countries. Whereas in the USA, Japan and southern European countries, a high prevalence of MRSA between 20 and 60% exists, the prevalence in the Netherlands and Scandinavian countries is less than 3%. In Germany, the number of MRSA infections has dramatically increased and is a serious problem in the form of hospital acquired infections. In the past 10 years, an alarming increase in the prevalence of MRSA from 2% to approximately 25% today has been observed. This prevalence varies between hospitals and even between wards in the same hospitals. A study carried between July 2004 and December 2005 which involves active surveillance done by the CDC from July 2004 through December 2005 showed that the large majority of invasive MRSA infections were still healthcare-associated (Klevens et al., 2007).

This is further supported in an additional study by the Association for Professionals in infection Control and Epidemiology, in which about 70% of the isolates were healthcare-associated (Jarvis, 2007). While 25 to 30% of people are colonized in the nose with staphylococcus, less than 2% are colonized with MRSA. (Gorwitz et al., 2008) When a person carries MRSA but shows no signs and symptoms of infection for *S. aureus* the most common body site colonized is the nose. About 20% of the human populations are long-term carriers of *S. aureus*. Healthcare-associated infections fall into two types: community-onset and hospital-onset. Clear understanding of the distinctions between these infections is important. Community-onset is defined as infections that occur in people with prior history of the presence of an invasive device at time of admission, history of MRSA infection or colonization, and hospitalization, surgery or long-term care residence in the 12 months preceding culture date (David and Daum, 2010). Hospital-onset is defined as cases with positive cultures isolated from hospitalized patients from a normally sterile body site obtained more than 48 h after hospital admission. Most MRSA infections are skin infections, more severe or potentially life-threatening MRSA occur most frequently among patients in health care settings (Baker et al., 2014).

A better understanding of the colonization and spread of MRSA coupled with alleviation of the different barriers to regular screening, prompt treatment and implementation of an effective preventive measure, will result in a significant reduction of the frequency of MRSA in hospitals (Alvarez et al., 2010). Furthermore, inadequate management of MRSA will lead to continuious spread of MRSA in our hospitals. Urgent measures like introduction of standard available screening methods, adequate outbreak management protocols, as well as control and use of antibiotic prescriptions, are needed. Therefore, the introduction of MRSA screening based on rapid and reliable diagnosis during, or before admission of patients in hospitals is indispensable and may be an ultimate solution to this major public health problem. This can only be achieved if health policy makers in developing countries and Cameroon in particular where there is limited data on the magnitude of MRSA could elaborate a good prevention strategy in this part of the world in order to help reduce the rate of morbidity and mortality from MRSA. This will lead to further investigations and will also enable us to obtain more data on the frequency of MRSA in Cameroon and help health authorities to decide on what strategies to adopt in order to reduce the incidence of MRSA in Cameroon.

MATERIALS AND METHODS

Study design

A prospective hospital-based study followed by a quantitative cross-sectional survey was carried out from January to June 2019 to ascertain risk factors associated with increasing prevalence of nosocomial methicillin-resistant *S. aureus* in hospitalized patients and medical staff age 18 years and above who consented to participate in the study were recruited from four units; surgery, intensive care unit, medicine and pediatric of in three hospital settings of two regions in Cameroon:Yaounde University Teaching Hospital (UTHY), Regional Hospital Buea (RHB) and Regional Hospital Limbe (RHL).

---

*Corresponding author. E-mail: leontinesinda@yahoo.com.

Data collection

After obtaining the appropriate written consent, hospitalized patients were requested to respond to a questionnaire on basic demographic characteristics (gender, residence, number of family members, profession of family, family income, family education), any potential risk factors (history of hypertension, diabetes, HIV, tuberculosis, renal disease, lower respiratory tract infection (LRTI), gastro-intestinal (GI) disease, upper respiratory tract infections (URTIs), recent surgery, chronic medical illness, previous and recent hospitalization, recent visit to out-patient departments (OPD), any recent medication, recent and prolong antibiotic use, recent visit to hospital where family members are admitted) and habitual factors (vehicle used by participants, vehicle used by participants' family members, recent visit to public amusement places, tattoo or acupuncture, alcohol consumption habit, contact with livestock and pets) during swab collection.

Exclusion criteria

The participants below 18 years old and those receiving either intranasal antibiotic ointment including mupirocin were excluded in this study.

Sample collection

Nasal swabs were collected using sterile cotton swabs previously moistened with 2 to 3 drops of 5% normal saline from the anterior nares of each nostril from each participant. Aseptic technique (disinfecting outer nostrils with alcohol) was followed while collecting the swab samples. The swab samples were transported within 2 h in Amie's transport media to the bacteriology/ microbiology laboratory of each study site and processed for bacteriological profile within half an hour of collection.

Microbiological study

Nasal swabs were processed according to good laboratory practice and standard methods for identification at the bacteriological laboratory of the University Teaching hospital center of Yaounde, and microbiology laboratory of Regional hospital Limbe. Nasal swabs from both nostrils were streaked on blood agar (BA) after primary enrichment on nutrient broth for 24 h at 37°C. Verification of staphylococci was performed by i) Plates evaluation ii) Blood agar inoculations iii) Gram stain, vi) positive catalase reaction, v) positive coagulase test, vi) positive DNase test. Suspected colonies were incubated on Mannitol Salt Agar (MSA) plates. Isolates displaying yellow growth in MSA plates were identified as *S. aureus* and subsequently verified by Analytical Profile Index (API). Identification of *S. aureus* was carried out following standard microbiological methods recommended by American Society for Microbiology (ASM) (Isenberg, 2004).

Identification of methicillin resistant strains (MRSA)

Identified isolates of *S. aureus* were screened for oxacillin resistance by 24 h incubation on Oxacillin Screen Agar (Mueller Hinton Agar, Oxacillin 5 µg/ml, 4% NaCl). The strains showing the diameter of the zone of inhibition (ZOI) of ≤10 mm with the oxacillin disk were recorded as methicillin resistant in accordance with National Committee of Clinical Laboratory Standards (NCCLS) for agar diffusion tests (Brown et al., 2005).

Antibiotic susceptibility test for MRSA

Antibiotic susceptibility tests were carried out by modified Kirby-Bauer method. Mueller Hinton agar plates were brought to room temperature; a bacterial suspension equivalent to a density of a Mac Farland no. 0.5 standard was prepared from each strain. The tip of the swab is put into the tube, excess fluid was removed from the swab by pressing against the side of the tube above the level of the suspension and surface area was inoculated by streaking the whole surface of the plate then rotate to 60° and streaked again. Plates were then covered, allowed to dry for 5 min and the tested antibiotics were aseptically placed with forceps 15 mm from the edge of the plates and no closer than 25 mm from disc to disc and also incubate at 37°C for 18- 24 h (Hudzicki, 2009). The zones of inhibition were measured and the disc contents were compared as recommended by the Clinical Laboratory Standards Institute (CLSI). Results obtained were reported as resistant, intermediate or sensitive. The same was done with the control strain ATCC 25923 for quality control.

Data analysis

Data was analyzed using Microsoft Excel and Stata 13. Binary logistic regression was used to identify multi drug resistance risk factors. Statistical significance was set at $p < 0.05$.

Ethical issues

Administrative authorization was obtained from Regional delegation of public health and ethical committee clearance from the institutional review boards of the different participating hospitals, informed consent was obtained from each participant.

RESULTS

This study was carried out between January – June 2019 and the study revealed that out of the 579 subjects screened out for nasal carriage of MRSA, overall 307 (53.1%) tested positive for *S. aureus.* This is higher than the prevalence of 28.95% obtained in a study at Laquintini hospital in Cameroon (Bissong et al., 2016) and that of three regions in Cameroon with an overall nasal carriage of 38% (Gonsu et al., 2013), but lower than that obtained in a study conducted in Asmara, Eritrea, which showed a prevalence rate of 63.1% (Garoy et al., 2019). Among the *S. aureus* positive, 158 (51.5%) were found in medical staff and 149 (48.5%) in hospitalized patients which is lower than the result obtained in another study on hemodialysis patients which recorded 53% (Lederer et al., 2007). 71 (45.2%) of *S. aureus* were identified in the YUTH, 68 (52.3%) in RHB and 149 (57.5%) in RHL. It was observed that one of the ecological niches for the colonization of staphylococci is the anterior nares, as most of the nasal specimens were positive for staphylococci. This confirms that staphylococci are part of normal flora of the anterior nares.

The present study showed a prevalence of 45.4% (263/579) of nasal carriage of MRSA (Figure 1), which is within the MRSA prevalence range for Africa according to
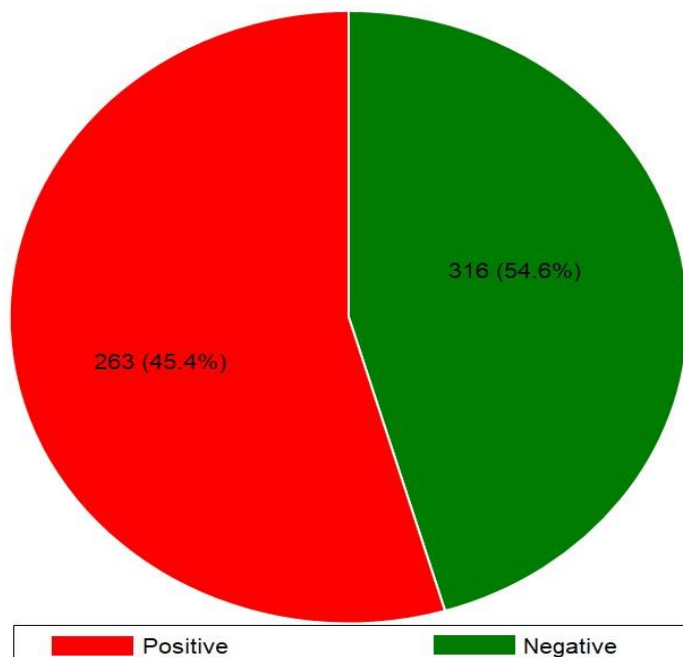
Figure 1. Overall prevalence of MRSA among hospitalized patients and medical staff in selected hospitals in Cameroon.

a literature review assessing burden of MRSA in Africa which stated that the prevalence of MRSA was lower than 50% in most African countries (Falagas et al., 2013), prevalence obtained in this study is higher than a result obtain in a study conducted in three regions in Cameroon which revealed a prevalence rate of 34.6% (Gonsu et al., 2013), but lower than that of a multicenter study conducted in Eritrea that obtained a result of 72% (Garoy et al., 2019), and that of 53.4% obtained in a study in East Africa (Wangai et al., 2019).

In Europe, MRSA prevalence varied almost a 100 fold in a study, from <1% in northern Europe to ≥50% in south Western Europe (ECDC, 2011). In the United States, the proportion of MRSA rapidly increased from below 5% in the 1980's to 29% in 1991. From the foregoing, it is clear that there is considerable variation of MRSA carriage within hospital settings, wards of the same hospital, regions and even countries. Generally, MRSA has become a global nosocomial pathogen with attendant therapeutic problems which could be due to its possible rapid spread and capacity to acquire resistance to commonly used antibiotics.

The prevalence of MRSA in nasal carriage was higher in hospitalized patients 46.82% (162/346) which is higher than that of a study conducted in Kwazulu-Natal which had a rate of 21% and lower in medical staff 43.35% (111/233), this is higher than results obtained in another study with a carriage rate of 27.2% in medical staff (Kumar et al., 2011). Statistically there was no significant difference (p = 0.413) in rates of MRSA carriage between medical staff and hospitalized patients. Regarding hospital

unit, the prevalence of MRSA in nasal carriage was significantly (p < 0.001) higher in the surgical ward (59.7%) and paediatric ward (45.2%) compared to the other units; this highlights the awareness level of the staff on implementation of preventive measures against nosocomial infections. On the other hand, the high prevalence of MRSA (38.8%) in medical unit could be attributed to lack of adequate precautions and very limited infection control applications. MRSA was identified in 25.9% of samples from intensive care unit this is lower than results obtained in a study conducted by Moniri et al. (2009), who recorded a prevalence of 75% in the intensive care unit. Results from several studies on MRSA in intensive care units have also revealed that MRSA colonization predisposed to MRSA infection during the same hospitalization period. The prevalence of MRSA in nasal carriage showed a significant variation with gender, hospital setting and units. In relation to gender, the prevalence of MRSA in nasal carriage was significantly (p = 0.001) higher in females (49.6%) than in males (34.0%). Concerning hospital setting, the prevalence of MRSA in nasal carriage was significantly (p = 0.027) higher in RHL (49.0%) and RHB (48.5%) compared to the UTHY (36.3%), (Table 1). Risk factors associated with nasal carriage of MRSA were analyzed using binary logistic regression model which showed that female participants (AOR=5.81, 95% CI: 2.02-11.02), being hospitalized or practicing at the RHB (AOR=3.45, 95% CI: 1.42–8.32), being hospitalized or practicing in the surgical unit (AOR=7.30, 95% CI: 3.14– 9.22), currently on antibiotics (AOR=5.08, 95% CI: 3.45-8.94)

Table 1. Variation of the prevalence of MRSA with age, gender, duration in hospital, hospital setting and hospital unit.

Category	MRSA		X^2	p-value
	Positive	Negative		
Overall	263 (45.4)	316 (54.6)		
By gender			11.290	0.001*
Male	53 (34.0)	103 (66.0)		
Female	210 (49.6)	213 (50.4)		
By age (years)			1.476	0.688
15 - 24	105 (47.5)	116 (52.5)		
25 - 34	88 (42.1)	121 (57.9)		
35 - 44	37 (47.4)	41 (52.6)		
35+	33 (46.5)	38 (53.5)		
Hospital setting			7.233	0.027*
UTHY	57 (36.3)	100 (63.7)		
RHB	63 (48.5)	67 (51.5)		
RHL	143 (49.0)	149 (51.0)		
Hospital unit			24.368	<0.001*
Medical	120 (38.8)	189 (61.2)		
ICU	7 (25.9)	20 (74.1)		
Surgical	108 (59.7)	73 (40.3)		
Paediatric	28 (45.2)	34 (54.8)		
Duration of hospitalization			5.891	0.117
1 - 7 days	74 (45.1)	90 (54.9)		
8 - 14 days	26 (40.0)	39 (60.0)		
15 - 30 days	48 (58.5)	34 (41.5)		
>30 days	12 (50.0)	12 (50.0)		

and having tuberculosis (AOR=10.10; 95% CI: 6.45-14.56) were the main risk factors that were strongly associated with MRSA in the nasal carriage of medical staff and hospitalized patients (Table 2). A high prevalence of MRSA resistance to most of the antibiotics used is of primary importance particularly among health care providers who may transmit these strains to patients during care delivery. The high frequency of MRSA resistance to antibiotics in this study was in accordance with other studies. Among the MRSA isolates, the maximum sensitivity was observed with vancomycin (97.0%) and minocycline (95.1%) in both medical staff and hospitalized patients while the least sensitivity was observed with penicillin (0.0%) and ampicillin (0.8%), (Figure 2).

The high susceptibility observed in vancomycin and Minocycline, may be due to the fact that they are relatively expensive, not commonly available and prescribed antimicrobial drugs in the present context, therefore less available for abuse. The highest rate of resistance in medical staff was recorded with penicillin (100.0%) while in hospitalized patients, penicillin and ampicillin had the highest rate of resistance. Amoxicillin

(21.0% vs 30.7%, p = 0.001), fusidic acid (64.8% vs 87.1%, p < 0.001) and ampicillin (0.0% vs 2.0%, p = 0.041) showed significantly lower sensitivity in hospitalized patients than in medical staff. rifampicin showed significantly (p < 0.001) higher sensitivity in hospitalized patients (43.2%) than in medical staff (22.8%) (Table 3).

Amoxicillin showed significantly (p = 0.033) higher sensitivity in hospitals in RHB (30.2%) and RHL (24.5%) compared to UTHY (19.3%). Rifampicin showed significantly (p = 0.011) higher sensitivity in UTHY (43.9%) compared to RHB (23.8%) and RHL (37.1%). Of the 263 isolates, 247 (93.9%) were resistant to three or more classes of antibiotics (Figure 3). Majority (51.7%) of the MRSA isolates were resistant to 5 classes of antibiotics. The prevalence of MDR to MRSA isolates in nasal carriage was significantly (p < 0.001) higher in hospitalized patients than in medical staff in the UTHY and RHL (Figure 4). The prevalence of MDR to MRSA isolates in nasal carriage was significantly (p < 0.001) lower in hospitalized patients (44.4%) than in medical staff (55.6%) in the RHB. The high level of resistance to these drugs in this study may be attributed to the fact that

Table 2. Risk factors of MRSA in nasal carriage of hospitalized patients and medical staff in selected hospital in Cameroon.

Variable	Categories	MRSA			
		UOR	(95%CI)	AOR	(95%CI)
Gender	Male	1		1	
	Female	**5.92**	**2.01 - 11.13**	**5.81**	**2.02 - 11.02***
Hospital setting	UTHY	1		1	
	RHB	**3.51**	**1.52 - 8.77**	**3.45**	**1.42 - 8.32***
	RHL	0.74	0.47 - 1.89	1.61	0.25 - 1.33
Hospital unit	Medical	1		1	
	ICU	0.71	0.28 - 2.98	0.67	0.36 - 2.12
	Surgical	**7.37**	**3.32 - 10.14**	**7.30**	**3.14 - 9.24 ***
	Paediatric	1.52	0.49 - 2.93	1.63	0.57 - 4.67
Duration of hospitalization	1 - 7 days	1		1	
	8 - 14 days	0.65	0.32 - 1.04	0.66	0.33 - 1.25
	15 - 30 days	0.72	0.44 - 1.47	0.71	0.41 - 1.45
	>30 days	0.38	0.11 - 2.03	0.41	0.12 - 2.11
Use of antibiotic	No	1		1	
	Yes	**5.01**	**2.54 - 8.93**	**5.08**	**3.45 - 8.94***
Diabetes	No	1		1	
	Yes	2.10	1.03 - 10.11	1.53	0.34 - 7.36
HIV infection	Negative	1		1	
	Positive	1.72	0.84 - 3.93	1.69	0.54 - 4.24
Tuberculosis	Negative	1		1	
	Positive	**10.23**	**7.35 - 15.34**	**10.10**	**6.45 - 14.56***

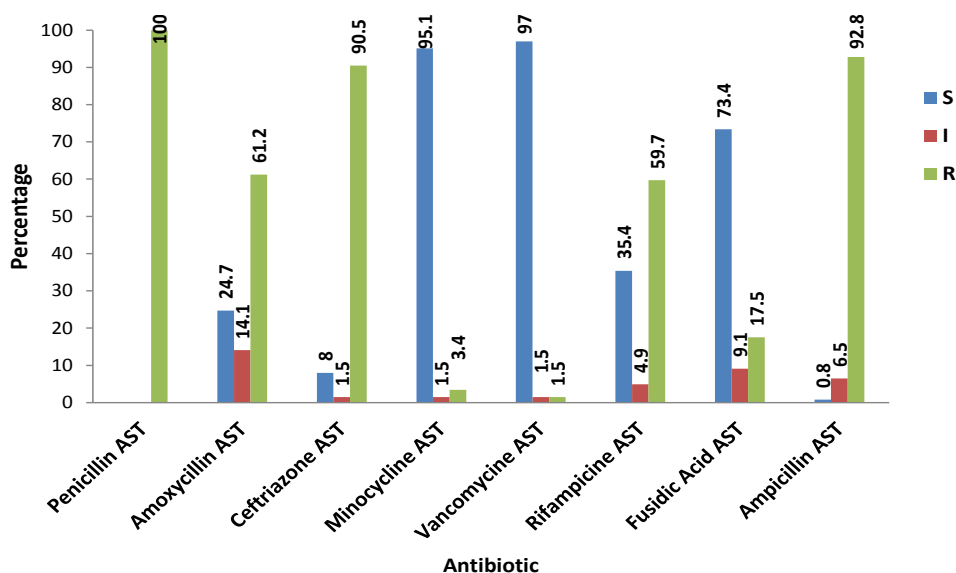UOR=Unadjusted Odds Ratio, AOR=Adjusted Odds Ratio, CI=Confidence Interval.

Figure 2. Antibiotic susceptibility pattern of identified MRSA in the study population.

Table 3. Susceptibility profile of MRSA isolates between medical staff and hospitalized patients.

| Antibiotic	Percentage susceptibility of MRSA isolates			χ2-value	p-value
	Medical staff (101)	Hospitalized patients (n = 162)	Total (n = 263)		
Penicillin	0 (0.0)	0 (0.0)	0 (0.0)	0.000	1.000
Amoxycillin	31 (30.7)	34 (21.0)	65 (24.7)	14.735	0.001*
Ceftriazone	10 (9.9)	11 (6.8)	21 (8.0)	3.251	0.196
Minocycline	97 (96.0)	153 (94.4)	250 (95.1)	2.649	0.266
Vancomycine	101 (100.0)	154 (95.1)	255 (97.0)	5.144	0.076
Rifampicin	23 (22.8)	70 (43.2)	93 (35.4)	23.896	<0.001*
Fusidic Acid	88 (87.1)	105 (64.8)	193 (73.4)	17.478	<0.001*
Ampicillin	2 (2.0)	0 (0.0)	2 (0.8)	6.395	0.041*
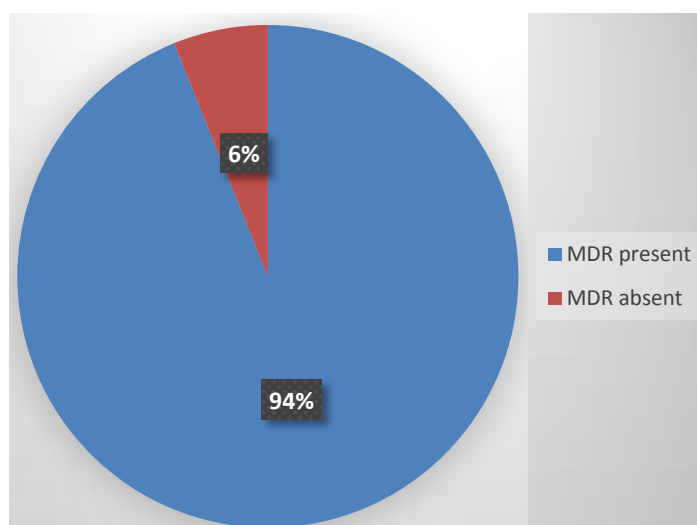
Figure 3. Prevalence of multiple drug resistance to MRSA isolates.
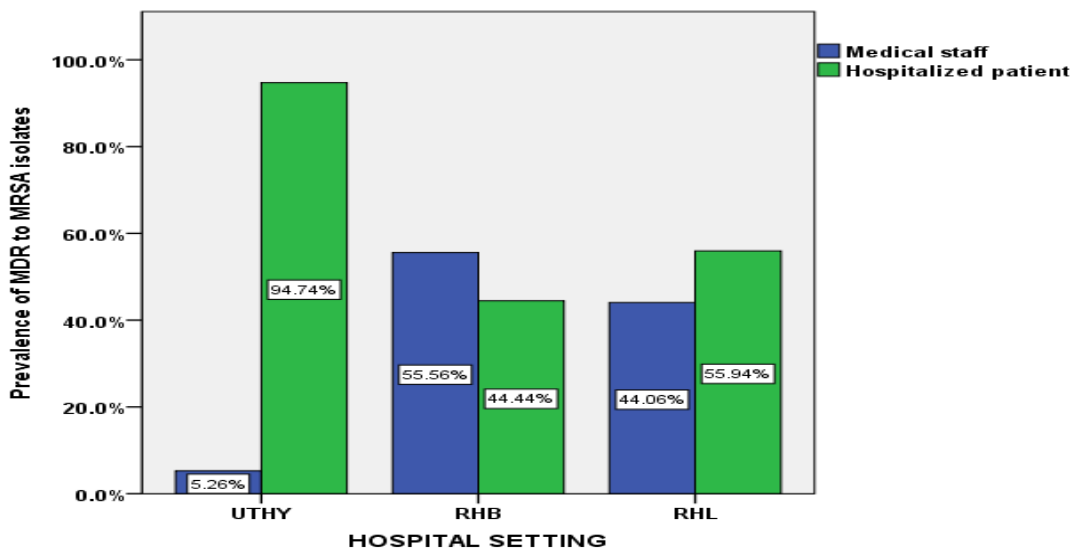

Figure 4. Variation of the prevalence of MDR to MRSA isolates by hospital setting and by participant type.

Table 4. Risk factors of MDR to MRSA in nasal carriage of hospitalized and medical staff in selected hospital in Cameroon.

Variable	Categories	MRSA			
		UOR	(95%CI)	AOR	(95%CI)
Age (in years)	15 - 24	1		1	
	25 - 34	0.91	0.41 - 1.97	0.92	0.44 - 1.85
	35 - 44	1.32	0.76 - 3.14	1.33	0.88 - 3.15
	35+	**2.51**	**1.02 - 4.04**	**2.53**	**1.22 - 4.54***
Gender	Male	1		1	
	Female	0.77	0.45 - 1.88	0.75	0.55 - 2.01
Hospital setting	UTHY	1		1	
	RHB	1.11	0.56 - 2.87	1.10	0.68 - 2.04
	RHL	0.95	0.45 - 2.31	0.94	0.44 - 2.13
Hospital unit	Medical	1		1	
	ICU	1.32	0.77 - 3.47	1.31	0.74 - 3.44
	Surgical	0.78	0.65 - 2.11	0.77	0.66 - 2.41
	Paediatric	0.98	0.42 - 2.31	0.95	0.44 - 3.01
Duration of hospitalization	1 - 7 days	1		1	
	8 - 14 days	1.02	0.31 - 2.45	1.01	0.42 - 2.65
	15 - 30 days	**2.51**	**1.07 - 4.11**	**2.53**	**1.04 - 4.09***
	>30 days	**3.02**	**1.05 - 5.62**	**3.03**	**1.06 - 5.74***
Use of antibiotic	No	1		1	
	Yes	0.95	0.35 - 2.11	0.96	0.61 - 2.15
Diabetes	No	1		1	
	Yes	1.21	0.87 - 3.02	1.20	0.84 - 3.04
HIV infection	Negative	1		1	
	Positive	1.01	0.65 - 2.14	1.02	0.68 - 2.44
Tuberculosis	Negative	1		1	
	Positive	1.11	0.65 - 2.14	1.12	0.68 - 2.44

UOR=Unadjusted Odds Ratio, AOR=Adjusted Odds Ratio, CI=Confidence Interval.

they have a wide clinical application, are inexpensive and are available from diverse sources where they are sold with or without prescription and therefore available for abuse. Binary logistic regression model showed that being aged 35 years an above (AOR=2.53, 95% CI: 1.22 – 4.54) and being hospitalized for more than 15 days (AOR=3.03; 95% CI: 1.06 – 5.74) were strongly associated with MDR to MRSA isolates in the nasal carriage of medical staff and hospitalized patients (Table 4). Multiple resistances are a common feature among commonly used antimicrobial agents.

DISCUSSION

S. aureus is a pathogen of public health interest worldwide due to its high median resistant rate above 50% (Njukeng et al., 2019). The *S. aureus* prevalence (53.1%) obtained in this study is higher than the result of 28.95% obtained in a study at Laquintini hospital in Cameroon (Bissong et al., 2016); but lower than that obtained in a study conducted in Asmara, Eritrea, which showed a prevalence rate of 63.1% (Garoy et al., 2019). It was observed that one of the ecological niches for the colonization of staphylococci is the anterior nares, as most of the nasal specimen yielded staphylococcal growth on culture. This confirms that Staphylococci are part of normal flora of the anterior nares.

The prevalence of MRSA (45.4%) obtained in this study is within the MRSA prevalence range for Africa. This was according to a literature review assessing burden of MRSA in Africa which stated that the prevalence of

MRSA was lower than 50% in most African countries (Falagas et al., 2013). On the other hand the prevalence observed in the current study is higher than that obtain in a study conducted in three regions in Cameroon which revealed a prevalence rate of 34.6% (Gonsu et al., 2013), and 46% for South Africa (Perovic et al., 2015), but lower than 53.4% obtained in East Africa (Wangai at al., 2019).

S. aureus is classified as high priority pathogen (WHO, 2019), that are resistant to most antibiotics used to treat staphylococcal infections in clinical settings. In Europe, MRSA prevalence varied almost a 100 fold in a study, from <1% in northern Europe to ≥50% in South Western Europe (ECDC, 2011). In the United States, the proportion of MRSA rapidly increased from below 5% in the 1980's to 29% in 1991 (Panlilio et al., 1992). Hence, it is clear that there is considerable variation of MRSA carriage within hospital settings, wards of the same hospital, regions and even countries. Generally, MRSA has become a global nosocomial pathogen with attendant therapeutic problems which could be due to its possible rapid spread and capacity to acquire resistance to commonly used antibiotics.

The prevalence of MRSA in nasal carriage in our study was higher in hospitalized patients 46.82% (162/346) than that of a study conducted in Kwazulu-Natal which had a rate of 21% (Scolt et al., 2011). Scolt and colleagues also showed a prevalence of 43.34% (111/233) in medical staff which was higher than 27.2% in medical staff in another study (Kumar et al., 2011); but this was lower than results obtained in a study in Uganda which showed a prevalence of 46% nasal carriage of MRSA among health care workers (Abimana et al., 2019). The high prevalence of MRSA in surgical and pediatric units highlights the awareness level of the staff on implementation of preventive measures against nosocomial infections.

Patients admitted in surgical units presented high risk of colonisation with MRSA this is in accordance with a study carried out by (Anderson et al., 2009) which states that Surgical site infections (SSI) represent the second most common type of healthcare associated *S. aureus* infection. Anderson and colleagues also showed 9 – 49% of *S. aureus* SSIs in the USA from 1992 to 2002 were caused by methicillin resistant strains. This is also in accordance with data obtained from the Centers for Disease Control and Prevention (CDC) which stated that the most common etiologic cause of SSI is *S. aureus*. In medical unit the rate of 38.8% could be attributed to lack of adequate precautions and very limited infection control applications and highlights the level of awareness in hospital staff on implementation of preventive measures against nosocomial infections. On the other hand, the prevalence of MRSA (26%) in ICU unit could be attributed to lack of adequate precautions and very limited infection control applications. This is lower than results obtained in a study who recorded a prevalence of 75% in the intensive care unit (Moniri et al., 2009).

Results from several studies on MRSA in intensive care units have also revealed that MRSA colonization predisposed to MRSA infection during the same hospitalization period.

Multiple resistances are a common feature among commonly used antimicrobial agents. A high prevalence of MRSA resistance to most of the antibiotics used is of primary importance particularly among health care providers who may transmit these strains to patients during care delivery. Although the high frequency of MRSA resistance to antibiotics in this study was in accordance with other studies, it may be attributed to the fact that they have a wide clinical application, are inexpensive and are available from diverse sources where they are sold with or without prescription and therefore available for abuse. On the other hand the high susceptibility observed in vancomycin and Minocycline, may be due to the fact that they are relatively expensive, not commonly available and prescribed antimicrobial drugs in the present context, therefore less available for abuse.

Therefore, it is clear that there is considerable variation of MRSA carriage between different regions, countries, hospital settings, and wards of the same hospital. Generally MRSA has become a global nosocomial pathogen with alarming therapeutic problems which could be due to its possible rapid spread and capacity to acquire resistance to commonly used antibiotics.

Conclusion

The prevalence of MRSA is high compared to other studies in Cameroon. Isolated strains of MRSA are highly resistant to most classes of antibiotics used in treating *S. aureus* infections but most are sensitive to vancomycin and minocycline. Nasal carriage of MRSA among hospitalized patients and medical staff is significant not only in terms of pre- disposing to subsequent infections, but it also play an important role in transmission among medical staff, patients and the community. Giving the high prevalence of MRSA nasal carriage and multidrug resistance in UTHY, RHB, RHL and their units (Surgical, Medical, pediatric and ICU), it is clear that epidemiological studies including genotyping are required to understand in detail, the dynamics of spread of MRSA. This calls for urgent intervention strategies to curb the possible rapid spread of MRSA and therapeutic problems that come with it.

ABBREVIATIONS

ASM; American Society for Microbiology, **BA;** Blood agar, **CDC;** Center for Disease Control, **ICU;** Intensive care unit, **MDR;** Multi drug resistance, **MHA;** Muller-Hinton agar, **MRSA;** Methicillin resistant *Staphylococcus*

aureus, **MSA;** Mannitol salt agar, **MSSA;** Methicillin sensitive *Staphylococcus aureus*, **NCCLS;** National committee for clinical laboratory standards, **ORSA;** Oxacillin resistant *Staphylococcus aureus,* **RHB;** Regional hospital Buea, **RHL;** Regional hospital Limbe, **USA;** United States of America, **UTHY;** University Teaching hospital Yaounde, **WHO**; World health Organization.

CONFLICT OF INTERESTS

No potential competing interest was reported by the authors.

ACKNOWLEDGEMENT

REFERENCES

Abimana JB, Kato CD, Bazira J (2019). Methicillin-resistant *Staphylococcus aureus* nasal colonization among healthcare Workers at Kampala International University Teaching Hospital, southwestern Uganda. Canadian Journal of Infectious Diseases and Medical Microbiology 2019:1-7.

Alvarez C, Labarca J, Salles M (2010). Prevention strategies for methicillin-resistant *Staphylococcus aureus* (MRSA) in Latin America. Brazilian Journal of Infectious Diseases 14(Suppl. 2):107-108.

Anderson DJ, Kaye KS, Chen LF, Schmader KE, Choi Y, Sloane R, Sexton DJ (2009). Clinical and Financial Outcomes Due to Methicillin Resistant *Staphylococcus aureus* Surgical Site Infection: A Multi-Center Matched Outcomes Study. PLOS ONE 4(12): e8305.

Baker AW, Durkin MJ, Dicks KV, Lewis SS, Moehring RW, Chen LF, Sexton DJ, Anderson DJ (2014). Methicillin-resistant *Staphylococcus aureus* bloodstream infection surveillance: National Healthcare Safety Network's laboratory-identified event reporting versus traditional laboratory-confirmed bloodstream infection surveillance. Infection Control and Hospital Epidemiology 35(10):1286–1289.

Bissong A, Ebob M, Therese W, Mbi AE, Peter TN, Frank ETF (2016). Prevalence and antibiotic susceptibility patterns of methicillin resistant *Staphylococcus aureus* in patients attending the Laquintinie Hospital Douala, Cameroon. European Journal of Clinical and Biomedical Sciences 2(6):92-96.

Brown D, Eddwards DI, Hawkey PM, Morrison D, Ridgway GL, Towner KJ, Wren MW, Joint Working Party of the British Society for Antimicrobial Chemotherapy, Hospital Infection Society, Infection Control Nurses Association (2005). Guidelines for the laboratory diagnosis of and susceptibility testing of methicillin-resistant *S. aureus.* Journal of Antimicrobial Chemotherapy 56:10001018

David MZ, Daum RS (2010). Community-associated methicillin-resistant *Staphylococcus aureus*: Epidemiology and clinical consequences of an emerging epidemic. Clinical Microbiology Reviews 23(3):616-687.

European Centre for Disease Prevention and Control (ECDC) (2011). Antimicrobial resistance surveillance in Europe 2010. Annual Report of the European Antimicrobial Resistance Surveillance Network (EARS-Net). Stockholm: ECDC.

Garoy EY, Gebreab YB, Achila OO, Tekeste DG, Kesete R, Ghirmay R, Kiflay R, Tesfu T (2019). Methicillin-Resistant *Staphylococcus aureus* (MRSA): Prevalence and Antimicrobial Sensitivity Pattern among

Patients-A Multicenter Study in Asmara, Eritrea. The Canadian Journal of Infectious Diseases and Medical Microbiology https://doi.org/10.1155/2019/8321834.

Falagas ME, Karageorgopoulos DE, Leptidis J, Korbila IP (2013). MRSA in Africa: Filling the Global Map of Antimicrobial Resistance. PLoS ONE 8(7):e68024.

Isenberg HD (2004). Clinical microbiology procedures handbook. 2nd ed. Washington: ASM Press 2004.

Gonsu KH, Kouemo SL, Toukam M, Ndze VN, Koulla SS (2013). Nasal carriage of methicillin resistant *Staphylococcus aureus* and its antibiotic susceptibility pattern in adult hospitalized patients and medical staff in some hospitals in Cameroon. Journal of Microbiology and Antimicrobials 5(3):29-33.

Gorwitz RJ, Kruszon-Moran D, McAllister SK, McQuillan G, McDougal LK, Fosheim GE, Jensen BJ, Killgore G, Tenover FC, Kuehnert MJ (2008). Changes in the prevalence of nasal colonization with *Staphylococcus aureus* in the United States, 2001-2004. The Journal of Infectious Diseases 197(9):1226–1234.

Hudzicki J (2009). Kirby-Bauer Disk Diffusion Susceptibility Test Protocol. American Society for Microbiology.

Jarvis WR (2007). The Lowbury Lecture. The United States approach to strategies in the battle against healthcare-associated infections, 2006: Transitioning from benchmarking to zero tolerance and clinician accountability. Journal of Hospital Infections 65:3-9.

Klevens RM, Morrison MA, Nadle J, Petit S, Gershman K, Ray S, Harrison LH, Lynfield R, Dumyati G, Townes JM, Craig AS, Zell ER, Fosheim GE, McDougal LK, Carey RB, Fridkin SK, Active Bacterial Core surveillance (ABCs) MRSA Investigators (2007). Invasive methicillin-resistant *Staphylococcus aureus* infections in the United States. Journal of the American Medical Association 298(15):1763-1771.

Kumar P, Shukla I, Varshney S (2011). Nasal screening of health care workers for nasal carriage of coagulase positive MRSA and prevalence of nasal colonization with *Staphylococcus aureus*. Biology and Medicine 3:182-186.

Moniri R, Musav GA, Fadavi N (2009). The prevalence of nasal carriage methicillin-resistant *Staphylococcus aureus* in hospitalized patients. Pakistan Journal of Medical Sciences 25(4):656-659.

Boon NA, Colledge NR, Walker BR, Hunter JAA (2008). Davidson's principles and practice of medicine 20th edition (pp. 313-314) Elsevier Health Sciences.

Njukeng PA, Ako-Arrey DE, Amin ET, Njumkeng C, Wirsiy FS (2019). Antimicrobial Resistance in the Central African Region: A Review. Journal of Environmental Science and Public Health 3:358-378.

Panlilio AL, Culver DH, Gaynes RP, Banerjee S, Henderson TS, Tolson JS, Martone WJ (1992). Methicillin-resistant *Staphylococcus aureus* in U.S. hospitals, 1975-1991. Infection Control and Hospital Epidemiology 13:582-586.

Perovic O, Iyaloo S, Kularatne R, Lowman W, Bosman N, Wadula J, Seetharam S, Duse A, Mbelle N, Bamford C, Dawood H, Mahabeer Y, Bhola P, Abrahams S, Singh-Moodley A (2015). Prevalence and Trends of *Staphylococcus aureus* Bacteraemia in Hospitalized Patients in South Africa, 2010 to 2012: Laboratory-Based Surveillance Mapping of Antimicrobial Resistance and Molecular Epidemiology. PloS One 10(12), e0145429.

Scolt K, Hey S, Sheela VS, Kathryn C, Tania AT, Geral F (2011). Prevalence of methicillin-resistance *Staphylococcus aureus* nasal carriage among hospitalized patients with tuberculosis in rural Kwazulu-Natal. South African Medical Journal 10(5):2078-5135.

Wangai FK, Masika MM, Maritim MC, Seaton RA (2019). Methicillin-resistant *Staphylococcus aureus* (MRSA) in East Africa: Red alert or red herring?. BMC Infectious Diseases 19(596).

World Health Organization (2019). Antibacterial agents in clinical development: an analysis of the antibacterial clinical development pipeline. Geneva: Licence: CC BY-NC-SA 3.0 IGO. ISBN 978-92-4-000019-3.