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# Carriage Rate of Methicillin-Resistant *Staphylococcus aureus* among Workers in Critical Care Units of a Tertiary Hospital in Southwestern Nigeria

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background:** Carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) among Healthcare workers (HCWs) who serves as agent of pathogen transmission in hospital settings portends danger to critical care patients.
**Aim:** To determine the carriage rate of MRSA among HCWs in the critical care units of the hospital, to identify the factors associated with carriage, and to determine the antibiotic resistance pattern of isolates.
**Study Design:** A cross sectional descriptive study.
**Materials and Methods:** A total of 135 randomly selected consenting HCWs from critical care

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units were studied. Data on demographic characteristics and infection control practices were obtained from participants with the aid of questionnaire. Swabs of the anterior nares and hands of participants were cultured on oxacillin-containing mannitol salt agar (MSA), *S. aureus* was identified using convectional criteria and MRSA was identified by cefoxitin disc diffusion technique. Antibiotic susceptibility testing was carried out on all isolated MRSA.

**Results:** Carriage rate of MRSA was high (26.7%). Poor handwashing practices (*P*=.008) and presence of wound or skin infection (*P*=.003) were associated with higher isolation rate. None of the age, gender, profession and duration of unit stay of workers was associated with carriage rate of MRSA. Isolation rate was higher from the nose (18.5%) than the hands (8.1%). Isolates demonstrated high resistance to antibiotics: penicillin (100%), amoxicillin/clavulanate (66.7%), cefuroxime (61.1%), ceftriaxone (63.9%), erythromycin (55.6%). All isolates were sensitive to vancomycin.

**Conclusion:** Carriage rate of MRSA among critical care unit staff was high in this study. There is urgent need for formulation of infection control policies and enforcement, to prevent MRSA spread among critical care patients.

*Keywords: Methicillin-resistant Staphylococcus aureus; critical care unit; antibiotic resistance.*

## 1. INTRODUCTION

Nosocomial infections caused by methicillin–resistant *Staphylococcus aureus* (MRSA) is a cause of serious health problem globally due to limitations in treatment options as this strain is usually resistant to array of antibiotics [1]. The challenges posed by MRSA are more serious when critically ill-patients are infected. Infections due to this strain of bacteria ranges from mild skin infections to serious invasive diseases such as septicaemia, pneumonia, endocarditis, and deep-seated abscesses. The strain had also been implicated in causation of toxinoses including food poisoning and toxic shock syndrome [2]. The outcome of infections due to MRSA especially in hospital patients is usually grave, in addition to prolonged hospital stay, higher cost of treatment and increased mortality [3,4]. Methicillin–resistant *S. aureus* may be hospital-acquired MRSA (HA-MRSA) or community-acquired MRSA (CA-MRSA) strains [5].

The largest reservoir for spread of MRSA is the asymptomatic carrier [6,7]. An asymptomatic carrier is a person colonized by the organism either in the nares, the hand, the sputum, urine, stool or open wound without showing any symptom of a disease related to the organism. The carrier may transmit the organism to others through their colonized hands or via aerosol released following sneezing. Healthcare workers who regularly mix with hospital and the community may be an agent of cross-transmission of HA-MRSA and CA-MRSA [5].

The hands of healthcare workers (HCW) are a major source of transmission of nosocomial pathogens. Activities leading to direct contact of HCW with patients' bodies and their body fluids or secretions and touching of contaminated environmental surfaces may lead to acquisition of pathogens in the hand of HCW especially in the face of poor adherence to infection control measures [8]. Also, nasal carriage among HCW had been documented as a cause of some nosocomial MRSA outbreak [9,10].

Local data on carriage rate of MRSA is scanty, however, Fadeyi e*t al* reported 52.5% carriage rate among critical care unit workers while Egwuatu *et al* reported overall carriage rate of 13.6% among HCWs and 26.7% among the critical care unit workers [11,12]. Lower carriage rates have been reported from foreign studies; Malini *et al* (10%), Singh *et al* (7.5%), and Khanal et al (3.4%) [13-15].

Screening for carriage of MRSA among HCWs is important in modern-day infection control for epidemiological investigations and decision making concerning barrier isolation [6,7,10]. Screening and eradication of MRSA from colonized HCW is a recognized and recommended part of infection control measures against this pathogen [16]. Other infection control measures include effective handwashing, control of antibiotic use, and isolation of colonized patients [7,10].

There has been no similar study to determine the carriage rate of MRSA among the staff of critical care units of our hospital, thus, the aim of this study was to determine the MRSA carriage rate among HCWs in critical care units of the hospital, to identify the factors associated with carriage of this strain and to determine the antibiotic resistance pattern of the MRSA. The findings will form the basis for formulation of MRSA control policy for our hospital and others in similar settings.

## 2. METHODS

### 2.1 Study Location

This prospective cohort study was carried out from January 2020 to April 2020 at a tertiary health facility in Ekiti, Nigeria.

### 2.2 Study Population and Sampling

This included 135 randomly selected consenting critical care unit workers (doctors, nurses, health attendants) of the hospital; adult Intensive care Unit (ICU), renal dialysis unit (RDU), and neonatal intensive care unit (NICU).

### 2.3 Data Collection

Data was collected with the aid of questionnaire and laboratory studies.

#### 2.3.1 Questionnaire study

With the aid of a pretested questionnaire, data of participants including the age, gender, profession, work location in the hospital, number of years spent in the unit, handwashing practices, presence of skin infection or wound on the skin, history of recent antibiotics use (<3 months of the survey) was taken.

Handwashing practices were graded into percentages after scoring the participants on 16 handwashing questions. Each correctly answered question was scored 1 mark while an incorrect answer or no response was scored zero. Thus, a maximum obtainable score was 16. Each participant's score was placed over 16 and converted to percentages. A score below 70% was accepted as poor practice while scores above 70% was accepted as good practice of handwashing.

#### 2.3.2 Laboratory study

With the aid of sterile swab sticks (Evans, UK) moistened with normal saline, the swabs of the anterior nares and palms of participants were taken and transported to the medical microbiology laboratory of the hospital. The swabs were promptly inoculated onto the oxacillin-containing mannitol salt agar (MSA). The swabs of palms were taken at least an hour after the last handwashing. Inoculated MSA agar plates were incubated overnight aerobically at 35$^{o}$C. *Staphylococcus aureus* was identified based on conventional criteria including colonial morphology, gram stain reaction, positive catalase, coagulase (tube) and DNAse tests as described by Collee *et al* [17].

Cefoxitin disc-diffusion method was used to confirm methicillin-resistance among all isolated *S. aureus* following the Clinical and Laboratory Standard Institute (CLSI) criteria [18]. A participant is considered a carrier when MRSA was isolated from either the anterior nare or the palms or both.

These antibiotics were tested against all isolated MRSA: penicillin (10 µg), erythromycin (15 µg), chloramphenicol (30 µg), cotrimoxazole (25 µg), cefuroxime (30 µg), ceftriaxone (30 µg), gentamicin (10 µg), amoxicillin/clavulanate (30 µg), ciprofloxacin (5 µg), clindamycin (2 µg), linezolid (30 µg) and quinupristin/dalfopristin (15 µg) using the modified Kirby-Bauer disc diffusion technique on Muellar Hinton Agar (MHA) and incubated at 35°C for 18-24 h. *Staphylococcus aureus* ATCC 25923 was used as the control strain. The result was interpreted following the CLSI criteria [18]. Resistance of isolated MRSA strains to vancomycin was tested using the E-test (bioMerieux).

### 2.4 Data Analysis

Data entry was done using Microsoft Excel version 2017 and analysis was done using SPSS software version 20. The results were presented in tables. Fisher's exact test was used in the case of small number. Statistical significance was accepted at $P$<0.05.

## 3. RESULTS

### 3.1 Distribution of Participants

Of the 135 HCWs included in the study, 30 (22.2%) were doctors and 54 (40.0%) were nurses, and 50 (37%) were working in the renal dialysis unit (Table 1).

### 3.2 Demographic Characteristics of Participant versus MRSA Isolation

The mean age of the participants was 32.883 + 8.438 years. The MRSA was isolated from only 36 (26.7%) of the total participants. Highest isolation rates of MRSA were seen in age-group 18-29 years (14, 29.2%), among doctors (10, 33.3%), and among adult ICU staff (16, 35.6%). Isolation of MRSA was higher among males (15, 37.5%) compared to female (21, 22.1%), but no significant difference was seen (χ2= 3.41, OR=2.11, *P*=.06) (Table 2).

### 3.3 Infection Control-related Issues and Association with MRSA Isolation

Isolation was higher among those with poor handwashing practice (15, 44.1%) compared to those with good handwashing practice (21, 20.8%), χ2=7.08, OR=0.33, *P*=.008, this is statistically significant. Isolation of MRSA was higher among those with presence of wound or skin infections (8, 66.7%) compared to those without wound or skin infection (28, 22.8%). Yate corrected χ2=8.65, OR=0.15 and Fisher exact *P*=.003, this is statistically significant (Table 3).

### 3.4 Site Distribution of MRSA Isolates

Only 25 (18.5%) of the total participants had MRSA isolated from their nose, while 8 (5.9%) had MRSA isolated from both hand and nose (Table 4).

### 3.5 Resistance Pattern of the Isolated MRSA to Antibiotics Tested

All (100%) isolates were resistant to penicillin (100.0%). Isolates also demonstrated high resistance to other antibiotics tested; cefuroxime (61.1%), ceftriaxone (63.9%), amoxicillin/clavulanate (66.7%). However, only 9 (25.0%) were resistant to clindamycin, and no isolate (0.0%) was resistant to vancomycin, linezolid and quinupristin/dalfopristin tested (Table 5).

**Table 1. Distribution of participants in different critical care units**

| Unit | Doctor n(%) | Nurse n(%) | Attendant n(%) | Non-clinical staff n(%) | Total n(%) |
|---|---|---|---|---|---|
| NICU | 11 (36.7) | 15 (27.8) | 12 (27.3) | 2 (28.6) | 40 (29.6) |
| ICU | 7 (23.3) | 18 (33.3) | 18 (40.9) | 2 (28.6) | 45 (33.3) |
| Renal Dialysis Unit | 12 (40.0) | 21 (38.9) | 14 (31.8) | 3 (42.9) | 50 (37.0) |
| Total | 30 (22.2) | 54 (40.0) | 44 (32.6) | 7 (5.2) | 135 (100.0) |

**Table 2. Demographic characteristics of participant versus MRSA isolation**

| Parameter | Number n(%) | MRSA isolated n(%) | χ2 value | *P*-value |
|---|---|---|---|---|
| **Age (years)** | | | 0.68 | .88 |
| 18-29 | 48 (35.6) | 14 (29.2)) | | |
| 30-39 | 50 (37.0) | 14 (28.0) | | |
| 40-49 | 28 (20.7) | 6 (21.4) | | |
| ≥50 | 9 (6.7) | 2 (22.2) | | |
| Mean age=32.883 + 8.438 years | | | | |
| **Sex** | | | 3.41 | .06 |
| Male | 40 (29.6) | 15 (37.5) | | |
| Female | 95 (70.4) | 21 (22.1) | | |
| **Number of years spent in unit** | | | 0.14 | .71 |
| <5 years | 79 (58.5) | 22 (27.8) | | |
| >5 years | 56 (41.5) | 14 (25.0) | | |
| **Profession** | | | 2.34 | .5 |
| Doctor | 30 (22.2) | 10 (33.3) | | |
| Nurses | 54 (40.0) | 16 (29.6) | | |
| Attendant | 44 (32.6) | 9 (20.5) | | |
| Non-clinical staff | 7 (5.2) | 1 (14.3) | | |
| **Unit** | | | 3.01 | .22 |
| NICU | 40 (29.6) | 10 (25.0) | | |
| ICU | 45 (33.3) | 16 (35.6) | | |
| Renal Dialysis unit | 50 (37.0) | 10 (20.0) | | |
| **Total** | 135 (100.0) | 36 (26.7) | | |

**Table 3. Infection control-related issues and association with MRSA isolation**

| Parameter | Number n(%) | MRSA isolated n(%) | χ2 value | *P*-value |
|---|---|---|---|---|
| **Handwashing practice** | | | 7.08 | .008 |
| Good | 101 (74.8) | 21 (20.8) | | |
| Poor | 34 (25.2) | 15 (44.1) | | |
| **Presence of wound or skin infection** | | | 8.65 | .003 |
| No | 123 (91.1) | 28 (22.8) | | |
| Yes | 12 (8.9) | 8 (66.7) | | |
| **Recent use of antibiotics** | | | 1.6 | .20 |
| No | 104 (77.0) | 25 (24.0) | | |
| Yes | 31 (23.0) | 11 (35.5) | | |
| **Total** | 135 (100.0%) | 36 (26.7%) | | |

**Table 4. Site distribution of MRSA isolates**

| Site | Frequency (n=135) n(%) |
|---|---|
| Anterior nare | 25 (18.5) |
| Hand | 11 (8.1) |
| Hand and Anterior nare | 8 (5.9) |
| Total | 36 (26.7) |

**Table 5. Resistance pattern of the isolated MRSA to antibiotics tested**

| Antibiotics | Resistance (n=36) n(%) |
|---|---|
| Penicillin | 36 (100.0) |
| Chloramphenicol | 11 (30.6) |
| Cotrimoxazole | 17 (47.2) |
| Cefuroxime | 22 (61.1) |
| Ceftriaxone | 23 (63.9) |
| Amoxicillin/clavulanate | 24 (66.7) |
| Erythromycin | 20 (55.6) |
| Ciprofloxacin | 10 (27.8) |
| Clindamycin | 9 (25.0) |
| Vancomycin | 0 (0.0) |
| Linezolid | 0 (0.0) |
| Quinupristin/dalfopristin | 0 (0.0) |
| Gentamicin | 9 (25.0) |

## 4. DISCUSSION

The high MRSA carriage rate (26.7%) among HCWs in the critical care units seen in this study is worrisome considering the impact of this organism on hospital patients, especially those in the critical care units who have higher tendencies of case fatality. High carriage rate of MRSA has been proven as a precursor for MRSA epidemics [19]. Since HCWs serves as agent of transmission of nosocomial pathogens to patients, carriage of this multidrug resistant strain by every 1 in 4 staff in critical care units warrants urgent need for infection control policies to stem the tide, and to eliminate all avenue for MRSA transmission in this setting and thus prevent epidemics and high case fatality among critical care unit patients. It is important to note that cases of MRSA as a cause of epidemics in hospital ICU with associated high case fatality has been reported in previous study [20] and such must be prevented in our setting. Also, further study to include all other healthcare units in the hospital is necessary to appreciate the magnitude of the problem in this setting.

Similar findings to ours was reported by Egwuatu et al in Lagos, Nigeria, where overall carriage rate among HCWs was 13.6% but 26.7% among the critical care unit workers, and Aila *et al* in Gaza in which 25.5% of all HCWs and 33.3% of ICU workers were carriers of MRSA [12,21]. A higher carriage rate of 52.5% was reported by Fadeyi *et al* in Ilorin, Nigeria**,** while lower rates were reported from other studies; Joachim *et al* in Tanzania, (15.6%), Malini *et al* in Bangalore (10%), Singh *et al* in Bhubaneswar (7.5%), and Khanal *et al* in Nepal (3.4%) [11,13-15,22]. The variability in the isolation rates in different studies may be explained by varying study designs, sample size, methods of detection of MRSA, varying level of adherence to infection control practices and the local prevalence of MRSA in different settings. Studies which detected MRSA in both the anterior nare and hands of the participants, like ours, are expected to detect higher rates compared to others where only nasal carriage of MRSA was detected. Khanal *et al* [15] excluded HCWs with history of upper respiratory tract infection, fever, recent nasal surgery, diabetes, immunocompromise, use of nasal medications, or antimicrobial therapy from their study and this may have contributed to a very low carriage rate of 3.4% reported. While there is an existent infection control program in our setting, adherence to, and practices of various infection control procedures is low and probably contributed to the high rate seen. Poor infection control program was also reported by Fadeyi *et al* [11] as contributing to the high carriage rate of MRSA (52.5%) seen in their study. This calls for urgent need to reinforce various infection control policies and program against transmission of MRSA from colonized HCWs to patients and vice-versa.

Higher isolation rate of MRSA from the nose (anterior nare) compared to the hands, seen in this study, were reported in similar studies; Fadeyi *et al,* [nose (39.6%) and hand (26.3%)], Malini *et al*, nose [(8.0%) and hand (2.0%) [11,13]. Hand colonization by microorganisms including MRSA tends to be transient due to handwashing for various reasons including non-clinical issues such as; before and after feeding, but colonization of the anterior nare tends to be persistent until treated. The most common treatment option for the nasal carriage of MRSA is the 2% mupirocin nasal ointment, however, muprocin is expensive and widely unavailable in our environment, and mupirocin resistant strains have been widely identified [23]. Other identified therapeutic options for eradicating nasal carriage of MRSA include clindamycin, fucidic acid, vancomycin, rifampin, and lysostaphin. Measure such as the use of antiseptic solution (chlorhexidine) for washing and shampooing has been proven to be effective in eradicating MRSA colonization. . Hexachlorophene powder may be used for eradication of perineal carriage [24,25].

Poor handwashing practice was associated with higher carriage of MRSA in this study. Such association however was not found in a study by Joachim *et al* in Tanzania, the difference in the findings may be as a result of differences in the methods of assessing handwashing practices in the two studies [22]. The finding in this study is expected, as good handwashing practices is one of the most important infection control measures for preventing transmission of hospital pathogens. Frequent hand washing has been documented as a potent measure for reducing the risk of MRSA carriage among HCWs since MRSA strains spread through contaminated hands [26]. While policy on handwashing is existent in our centre, previous study in the setting revealed generally poor handwashing knowledge in which only 31.1% of HCWs had good knowledge of handwashing and only 16.46% had previous training on handwashing, also, most (68.6%) respondents in that study still relied on ‘stored’ water (rather than tap/running water) for the purpose of handwashing while hand drying facility available to most respondents (86.28%) was the common towel (shared by all after handwashing) and no respondents ever used paper towel [27]. All these findings showed poor adherence to existing policies on handwashing in our setting. Adherence to handwashing policies and regular training and retraining of staff on handwashing will help in reducing MRSA carriage rate in different healthcare facilities.

The presence of wound or skin infection on participants was associated with higher carriage of MRSA in this study. Presence of skin or soft tissue infection is one of the documented risk factors for carriage of MRSA [28]. This finding calls for the need to formulate infection control policy which considers treatment and temporary removal from work of HCWs with florid wound or skin infections, which cannot be easily covered. Such measures will go a long way in reducing transmission of MRSA in most healthcare settings. Other documented risk factors for MRSA carriage include; prolonged stay in care facility, recent hospitalization, long-term treatment with antibiotic, surgical intervention, and chronic underlying disease [28]. Carriage rate was not found to be associated with prolonged stay in care unit and previous antibiotic use in this study probably because of the small sample size, thus a bigger study involving all the hospital units is highly desirable in future.

The multi-drug resistant (MDR) pattern (resistance to at least one antimicrobial drug in 3 or more categories of antibiotic at a given point in time) [29] shown by the isolated MRSA in this study where high resistance to the cell wall inhibitors, protein synthesis inhibitors and the antifolate antibiotics was seen, is the main threat posed by this pathogen which leads to limited treatment options, increased morbidity, prolonged hospital stay, and in the case of critical care patients, increased fatality rates [3,4]. Interestingly in this study though, no resistance was seen against vancomycin. This drug is not in common use in our environment due to high cost and reduced availability, thus, the risk of accelerated generation of resistance to it by MRSA in our environment is low. Vancomycin remains the treatment of choice for infections due to MRSA, though; there have been reports of emergence of vancomycin-resistant strains which further worsen the options of treatment [30]. Linezolid, ceftaroline, telavancin and quinupristin/dalfopristin are other options in such cases. Most previous similar studies have reported similar resistance pattern of MRSA isolated from carrier HCWs [11,22]. This resistance pattern is a red alert for health managers to swing into action towards instituting and enforcing adherence to different infection control policies which among other things will reduce transmission of hospital pathogens including MRSA, and rationalize antibiotic use, thus reducing generation of multidrug resistant pathogens. Future study to determine the sensitivity of nasal MRSA isolates to mupirocin and detection the clindamycin-inducible resistance of MRSA among HCWs is highly desirable. Also, future study to determine the prevalence of MRSA infection rates among patients of our critical care units is recommended.

## 5. CONCLUSION

Isolation of MRSA was high among HCWs in critical care units. Poor handwashing practice and presence of wound or skin infection were associated with higher isolation rate of MRSA. Isolates demonstrated high resistance to commonly used drugs. No isolate was resistant to vancomycin. There is need for formulation of different infection control policies to curtail transmission of MRSA and reduce generation of antibiotic resistance.

## CONSENT AND ETHICAL APPROVAL

Ethical approval for the work was obtained from the Ethic and Research committee of the Federal Teaching Hospital, Ido-Ekiti, Nigeria and written informed consent was obtained from all participants prior to administration of questionnaire and sample collection.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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