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Staphylococcus aureus nasal carriage among healthcare workers, inpatients and caretakers in the Tamale Teaching Hospital, Ghana

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ABSTRACT

Background: *Staphylococcus aureus* associated nosocomial infection is an important health challenge as isolates may involve multidrug resistant strains. Sources of *S.aureus* infection in healthcare settings include colonized healthcare workers, inpatients, and caretakers. This study investigates *S. aureus* carriage rate and associated antimicrobial resistance among healthcare workers, inpatients, and caretakers in the Tamale Teaching Hospital (TTH), Ghana.

Methods: Nasal swabs and demographic data were collected from a cross-section of healthcare workers, inpatients, and caretakers. The swabs were culture and *S. aureus* isolates subjected to antibiotic susceptibility assay.

Results: Results: *S. aureus* nasal carriage rate was 25.5% (27/106) while MRSA and non-MRSA prevalence were 8.5% (9/106) and 17.0% (18/106) respectively. The proportion of *S. aureus* carriage distribution was highest among neonates 42.1% (8/19), follow by participant in the age group 11–20 years, 36.8% (7/19). Inpatients, healthcare workers, and caretakers recorded *S. aureus* carriage rate of 30.0% (15/50), 27.8% (10/36), and 10% (2/20), respectively. Healthcare workers had the highest proportion of MRSA 40% (4/10) and inpatients recorded a rate of 33.3% (5/15), while no case of MRSA was recorded among caretakers. Antibiotic resistance pattern of the isolates was generally higher in MRSA compared to non-MRSA.

Conclusions: There exist relatively high rate of *S. aureus* nasal carriage among healthcare workers, inpatients, and caretakers in the wards/units of the TTH. However, MRSA were only isolated from healthcare workers and inpatients but not caretakers.

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Introduction

Staphylococcus aureus is an important pathogenic bacteria, and a component of the human microbiome. It resides predominantly in the anterior nares, and extra-nasal sites including the skin, perineum, and pharynx, and less frequent in the gastrointestinal tract and the vagina [1,2]. About 30% of the general population are nasal carriers of the bacterium [3]. Infections caused by this organism could be exogenous or endogenous in origin, and they include impetigo, cellulitis, osteomyelitis, endocarditis, toxic shock syndrome (TSS), septicemia, and pneumonia [4].

S. aureus associated nosocomial infection remains a major health challenge as colonized healthcare workers, patients, and contaminated surfaces serve as reservoir for infection. The incidence of nosocomial infection caused by *S. aureus* continues to increase worldwide [5], particularly in resource poor countries where infection prevention is likely to be comprised due to scarcity of logistics. Depending on the source of infection, *S. aureus* infection could be categorized into two; health-care associated *S. aureus* infection and community-associated *S. aureus* infection [6]. Even though staphylococcal infections frequently occur in hospitalized patients, and the accompanying consequences are enormously adverse, eliciting both economic and health effects [7]. Reports suggest most of such infections can be prevented by topically treating nares carriers [8]. In addition, identification of *S. aureus* colonized patients and healthcare workers, coupled with strict adherence to infection prevention protocols have proven to be effective in reducing or preventing the spread of staphylococcal infections [9].

Another medically important challenge associated with *S. aureus* is the development of multidrug resistant strains to most of the available antibiotics. Because antibiotics are widely used in healthcare facilities, colonized healthcare workers commonly carry multidrug resistant strains, and *S. aureus* infections resulting from such persons are difficult to treat. These strains are usually resistant to several of the commonly used antibiotics including MRSA and Vancomycin resistant or intermediate *S. aureus* (VRSA/VISA) [4,10]. Because infections resulting from such strain are difficult to treat, the resultant effects include prolonged hospitalization and increase cost of healthcare [11]. Periodic screening of caretakers and healthcare personnel to identify carrier persons will be critical to preventing *S. aureus* associated nosocomial infection in healthcare settings.

Nosocomial infection by *S. aureus* is about 20% worldwide [1]. *S. aureus* nosocomial infection is the most common in North American (26.0%), Latin America (21.0%) and the second most common in Europe (19.5%) [3]. In Ghana *S. aureus* nosocomial infection rate is relatively high, with an estimated nasal carriage rate of 23.3% among healthcare workers, and 13.9% in inpatients [12]. The ecological niche and virulence nature of *S. aureus* coupled with the rising concerns of antibiotics resistance, could justify the need for healthcare facilities monitor the nasal carriage rate of their staff, patients, and caretakers in order to pre-empt possible sources of *S. aureus* associated outbreaks.

In Ghana, there exist limited reports regarding *S. aureus* nasal carriage rate among healthcare workers as it is not mandatory for healthcare workers to know their *S. aureus* carrier status. This could contribute to a possible shortfall in our infection prevention protocols. One could therefore envisage possible *S. aureus* transmission from a colonized healthcare worker to a patient and vice versa, especially in the Intensive Care Units (ICU), Surgical Wards, Neonatal Intensive Care Unit (NICU) and Aseptic Wards. Based on this background, this study aimed to determine the *S. aureus* nasal carriage rate and antibiotic susceptibility pattern of isolates among healthcare workers, inpatients and their caretakers in the TTH.

Methods

Study design and study area

A hospital based cross-sectional prospective study was employed, and span from May to July, 2016. The study was conducted in selected wards and units of the TTH. The TTH is the only teaching hospital in the Northern region of Ghana and the main referral hospital for the other regions in the northern part of the country. It lies on longitude 9° 24′ 0″ to the north and latitude 0° 50′ 0″ to the west. The Hospital is located in the Eastern part of the Tamale Metropolis. The metropolis has a total land surface area of 490,000 m^2, out of which 122,500 m^2 has been developed. The hospital is located in a catchment area which has an estimated population of 2.1 million.

Study population, sampling, specimens and data collection

The population for the study comprised of patient on admission, caretakers and healthcare workers in the neonatal intensive care unit (NICU), Pediatric ward, Surgical ward, Maternity ward, Medical wards and the Laboratory Department of the TTH. A total of 106 participants willingly accepted to participate in the study, comprising 36 healthcare workers, 50 inpatients and 20 caretakers. A simple random sampling technique was used to select participants from the various units and wards. None of the participants reported of complications or infection involving the ear, nose or throat. After explaining the experiment procedure to participants, nasal swabs were gently collected using sterile cotton swabs (Becton, Dickinson and Company), and temporary stored in peptone water for transport and subsequent culture. Additionally, structured closed and opened ended questionnaires were used to extract data on participants' demography.

Specimen culture

The nasal swabs were inoculated on Blood agar plate (BAP) and Mannitol salt agar plate (MSA) (CRITERION, USA), and incubated at 37 °C for 18 to 24 h as described previously [13]. The cultures were examined and recorded according to

standard protocol. Presumptively, *S. aureus* colonies appear yellowish suggesting fermentation of mannitol on MSA plates after 18 to 24 h of incubation. Purity plating was performed on culture plates with mixed bacteria growth to obtain pure discrete colonies. Following purity plating, Gram's staining was performed to establish the Gram reaction of the cultures as described previously [13].

Catalase tests

Catalase test was done on all colonies (test organism) confirmed as Gram positive cocci to separate staphylococci from streptococci. A colony from purity plating was added to a drop of 3% hydrogen peroxide (3% H_2O_2) on a microscope slide. Staphylococci colonies produce bubbles in H_2O_2 while streptococci do not.

Coagulase test

Tube coagulase tests was done on cultures confirmed to be *Staphylococcus* per the Gram's staining and the catalase test. Three test tubes were prepared and labelled; Test (T), Positive control (Pos) and Negative control (Neg). Plasma and peptone broth was prepared in the ratio 1:4. e.g. 0.2 ml of plasma to 0.8 ml of peptone. 0.2 ml of plasma was added to each of the tubes. 0.8 ml of sterile peptone was added to the Neg tube, and same volume of a suspension of the test organism added to the tube labeled T while 0.8 ml of control *S. aureus* suspension was added to the tube labeled Pos. The suspensions were homogeneously mixed and incubated at 37 °C for 18 to 24 h, and examined macroscopically for the presence of clot.

Antibiotic sensitivity test

Antibiotic susceptibility test was performed in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines [14]. Colony suspensions were prepared and their turbidity brought to an equivalent of a 0.5 McFarland standard. A sterile cotton swab was dipped into the test suspension, withdrew gently from the inoculum, pressed and rotated against the side of the tube above the suspension to avoid using excess inoculum and then inoculated on a plate of Mueller Hinton agar (Oxoid Ltd, UK) by seeding the entire surface of the medium in three directions rotating the plate approximately 60° to ensure even distribution. The Petri dish with the lid in place was allowed 5 min for the surface of the agar to dry. The seeded agar was overlaid with antibiotic discs including Oxacillin (Axion Medical Ltd, U.K.) for MRSA identification. The plates were inverted and incubated aerobically at 37 °C for 24 h. The diameter of zone of inhibition were compared to standards provided by the CSLI to determine whether the isolate is resistant to a particular antibiotic or otherwise.

Data analysis

The data from the study were entered into Microsoft excel spread sheet for data cleaning. The cleaned data was exported to SPSS 16.0 software for analysis. Descriptive statistics were used to establish frequencies of various variables.

Ethical considerations

Approval for the study was given by the Tamale Teaching Hospital Research Ethics Committee with approval number TTHERC/24/05/16/01. The consent of all participants was sought prior to the study and only those who agreed to be part of the study were included. In the case of minors, their parents gave consent.

Results

Demographic characteristics of the study population

A total of 106 participants were included in the study, and majority were females 61.3% (65). Nineteen of the study participants were neonates (17.9%), while the rest ranged from 1 to 40 years in age, and the dominant age bracket was 21–30 years constituting 39.6% (42). Education-wise, majority of the study participants had tertiary education 42.5% (45), followed by primary 21.7% (23), pre-school 18.9% (20) and secondary 14.2% (15) education. Only 2.8% (3) had no formal education. Grouping the participants into occupational status, healthcare workers were 33.0% (35) and non-healthcare workers were 26.4% (28), Table 1.

Distribution of nasal S. aureus *carriage among the study participants*

Out of the 106 participants, 25.5% (27) carried *S. aureus* in their nares and they were predominantly males 31.7% (13/41) compared to females 21.5% (14/65). Neonates, which formed 17.9% (19/106) of the total participants had nasal *S. aureus* rate of 42.1% (8/19). Participants in the age group 21–30 years had carriage rate of 21.4% (9/42), and the age bracket 11–20 years recorded a rate of 36.8% (7/19), whiles the lowest nasal *S. aureus* carriage rate was noted among participants in the age group >30 years 10.5%(2/19). Inpatients had the highest nasal *S. aureus* rate of 30.0% (15/50), followed by healthcare workers 27.8% (10/36), while caretakers had the lowest rate of 10% (2/20). The NICU had the highest nasal *S. aureus* carriage rate of 28.6% (10/35) in terms of ward/unit, whiles maternity ward had the least rate of 11.1% (1/9), Table 2.

Table 1
The study participants' demographic information.

Age	Frequency	Percent
<1 month	19	17.9
1–10 years	7	6.6
11–20 years	19	17.9
21–30 years	42	39.6
>30 years	19	17.9
Total	106	100.0
Sex		
Female	65	61.3
Male	41	38.7
Total	106	100.0
Educational level		
None	3	2.8
Pre-school	20	18.9
Primary	23	21.7
Secondary	15	14.2
Tertiary	45	42.5
Total	106	100.0
Marital status		
Married	36	34.0
Not married	70	66.0
Total	106	100.0
Occupation		
Healthcare workers	35	33.0
Non-healthcare workers	28	26.4
Students	21	19.8
Others	22	20.8
Total	106	100.0

Table 2
Staphylococcus aureus nasal carriage distribution among the study population.

Age	*n*	*S. aureus* carriage (*n*)	%
<1 month	19	8	42.1
1–10 years	7	1	14.3
11–20 years	19	7	36.8
21–30 years	42	9	21.4
>30 years	19	2	10.5
Total	106	27	25.5
Sex			
Female	65	14	21.5
Male	41	13	31.7
Total	106	27	25.5
Category			
Caretaker	20	2	10.0
Healthcare worker	36	10	27.8
Inpatient	50	15	30.0
Total	106	27	25.5
Ward/unit			
Laboratory	12	3	25.0
Maternity	9	1	11.1
Medical	23	5	21.7
NICU	35	10	28.6
Pediatric	16	4	25.0
Surgical	11	3	27.3
Total	106	27	25.5

Key: NICU = Neonatal intensive care unit.

Prevalence of MRSA among the study population

MRSA in the study population was 8.5% (9/106). However, out of the 27 *S. aureus* isolated, 33.3% (9/27) were methicillin-resistant. Among *S. aureus* nasal carriers, the proportion of females with MRSA was 35.7% (5/14) whiles that of males was 30.8% (4/13). Also, neonates had MRSA prevalence of 50.0% (4/8) and participants in the age group >30 years had MRSA prevalence of 100% (2/2) whiles no case was recorded among those in the age bracket 1–10 years. Healthcare workers had

Table 3
Prevalence of MRSA among *S. aureus* nasal carriers in the study population.

AGE	*S. areus* (*n*)	MRSA (*n*)	%
<1 month	8	4	50.0
1–10 years	1	0	0.0
11–20 years	7	2	28.6
21–30 years	9	1	11.1
>30 years	2	2	100.0
Total	27	9	33.3
SEX			
Female	14	5	35.7
Male	13	4	30.8
Total	27	9	33.3
Category			
Caretaker	2	0	0.0
Healthcare worker	10	4	40.0
Inpatient	15	5	33.3
Total	27	9	33.3
WARD			
Laboratory	3	2	66.7
Maternity	1	1	100.0
Medical	5	0	0.0
NICU	10	4	40.0
Pediatric	5	1	20.0
Surgical	3	1	33.3
Total	27	9	33.3

Key: NICU = Neonatal intensive care unit, *n* = number of *S. aureus* isolated.

Table 4
S. aureus resistance and susceptibility to selected antibiotics.

Antibiotics	Resistant (*n*)	%Resistant	Sensitive (*n*)	%Sensitive	Total (*n*)
AMX	22	81.5	5	18.5	27
ERY	22	81.5	5	18.5	27
TET	21	77.8	6	22.2	27
CTX	13	48.1	14	51.9	27
COT	12	44.5	15	55.5	27
CIP	7	25.9	20	74.1	27
ROX	7	25.6	20	74.1	27
AZM	5	18.5	22	81.5	27
LM	5	18.5	22	81.5	27
SPX	5	18.5	22	81.5	27
GEN	3	11.1	24	88.1	27
LEV	2	7.4	25	92.5	27

Key: *n* = number of *S. aureus* isolated. AMX = Amoxicillin, COT = Cotrimoxazole, AZM = Azithromycin, TET = Tetracycline, CTX = Cefotaxime, CIP = Ciprofloxacin, LEV = Levofloxacin, SPX = Sparfloxacin, ERY = Erythromycin, LM = Lincomycin, GEN = Gentamycin, ROX = Roxythromycin.

the highest proportion of MRSA 40% (4/10) whiles inpatients recorded a rate of 33.3% (5/15), and no case of MRSA was recorded among caretakers. The Laboratory unit and NICU had MRSA rate of 66.7% (2/3) and 40% (4/10) respectively whiles no MRSA case was isolated from *S. aureus* nasal carriers in the medical ward, Table 3.

S. aureus *isolates' response to selected antibiotics*

As indicated in Table 4, out of the 27 *S. aureus* isolated 81.5% (22) of the isolates were resistant to amoxicillin (AMX) and erythromycin (ERY), and 77.8% (21) were resistant to tetracycline (TET). The isolates showed highest resistance to these three antibiotics. Also, 48.1% (13) and 44.5% (12) of the isolates demonstrated resistance to cefotaxime (CTX) and cotrimoxazole (COT) respectively, while 18.5% (5) were resistant to azithromycin (AZM), sparfloxacin (SPX) and lincomycin (LM). The antibiotic to which the isolates showed the least resistance was levofloxacin (LEV) 7.4% (2/27), whiles 11.1% (3/27) of the isolates were resistant to gentamycin (GEN).

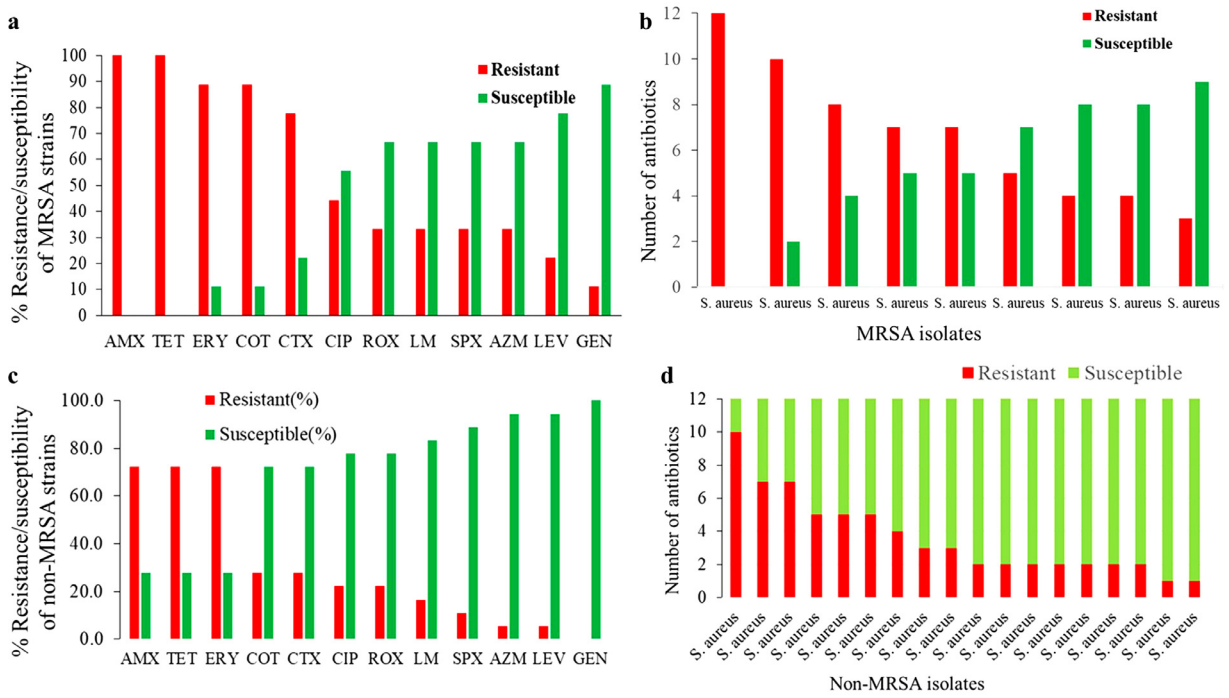

Fig. 1. Isolates' resistance and susceptibility to the antibiotics tested. (a) and (c) Percentage resistance or susceptibility of isolates. (b) and (d) Number of antibiotics individual isolates are resistant or susceptible. AMX = Amoxicillin, COT = Cotrimoxazole, AZM = Azithromycin, TET = Tetracycline, CTX = Cefotaxime, CIP = Ciprofloxacin, LEV = Levofloxacin, SPX = Sparfloxacin, ERY = Erythromycin, LM = Lincomycin, GEN = Gentamycin, ROX = Roxythromycin.

MRSA and non-MRSA antibiotics susceptibility pattern

The isolates were further stratified into MRSA and non-MRSA. Some of the MRSA isolates were resistant to more than 70% of the 12 antibiotics tested, and these included AMX, ERY, TET, CTX, and COT, with AMX and ERY recording 100% resistance. Contrarily, other MRSA isolates were susceptible to more than 50% of the antibiotics tested and these included AZM, ciprofloxacin (CIP), SPX, GEN, roxythromycin (ROX), LM, and LEV, and the greatest susceptibility was observed in LEV (88.9%) Fig. 1(a) and (b). Additionally, MRSA isolates were not just predominantly from NICU and pediatric inpatients but they also demonstrated the highest degrees of resistance, with one of the isolates showing resistance to all the antibiotics tested (Table 5).

Relatively less resistance was demonstrated by the non-MRSA isolates. More than 70% of the isolates were susceptible to the antibiotics tested, and AMX, TET, ERY which exhibited 100%, and 88.9% resistance, respectively in MRSA, all showed 72.2% resistant in non-MRSA. AZM, LEV, and GEN were more effective against varying non-MRSA compared to MRSA isolates (Fig. 1(c) and (d)). Resistance of non-MRSA isolates was highest in healthcare workers in the Medical ward, while greater susceptibility was seen in isolates from inpatients from the NICU and Medical ward (Table 5).

Discussion

The prevalence of nasal *S. aureus* carriage in this study was 25.5%, which agrees with Shakya et al. who reported similar finding (25.0%) at the National Medical College Teaching Hospital, Birgunj [15]. Also, our finding agrees with a similar study conducted in Ghana which reported a carriage rate of 22.6% [16]. Additionally, our results is in consonance with other studies conducted in Chile (27.5%) and Dessie, Northeast Ethiopia (28.8%) [17,18]. The rate established in the current study also fall within the global persistent nasal *S. aureus* carriage rate of 12–30% [1]. Comparatively, the observation made in this study is relatively lower than 30.8% reported by Shibabaw et al. [19] and 34.9% by Yazgi et al. [17], but relatively higher than 13.9% reported in Ghana [12].

S. aureus carriage rate among hospitalized neonates was 42.1% (8/19) in this study. Neonatal nasal *S. aureus* carriage prevalence could range between 36% and 61% [20,21]. The reasons for the high rates among neonates remain unclear. Possibly, colonization from parents, caregivers or healthcare workers plays a critical role. Other possible reasons in our case could be cross contamination or infection from one baby to the other by healthcare workers transiently carrying the bacteria with contaminated hands. Additionally, cross contamination could also happen among babies as it is common to pair neonates in one incubator or under radiant warmers for lack of space. The carriage rate dipped among participants in age 1–10 years (14.3%) and peaked among those aged 11–20 years (36.8%). The relatively high prevalence of the organism among younger

Table 5
Staphylococcus aureus isolates per category and Ward/Unit.

MRSA				
Isolates	Resistant (*n*)	Susceptible (*n*)	Category	Ward/Unit
S. aureus	12	0	Inpatient	NICU
S. aureus	10	2	Inpatient	NICU
S. aureus	8	4	Inpatient	NICU
S. aureus	7	5	Inpatient	NICU
S. aureus	7	5	Inpatient	Pediatric
S. aureus	5	7	Healthcare worker	Maternity
S. aureus	4	8	Healthcare worker	Surgical
S. aureus	4	8	Healthcare worker	Laboratory
S. aureus	3	9	Healthcare worker	Laboratory
Non-MRSA				
Isolates	Resistant (*n*)	Susceptible (*n*)	Category	Unit/Ward
S. aureus	10	2	Healthcare worker	Medical
S. aureus	7	5	Inpatient	Pediatric
S. aureus	7	5	Healthcare worker	Medical
S. aureus	5	7	Inpatient	Medical
S. aureus	5	7	Caretaker	NICU
S. aureus	5	7	Healthcare worker	NICU
S. aureus	4	8	Caretaker	Surgical
S. aureus	3	9	Healthcare worker	Surgical
S. aureus	3	9	Inpatient	NICU
S. aureus	2	10	Inpatient	Pediatric
S. aureus	2	10	Inpatient	Pediatric
S. aureus	2	10	Inpatient	Pediatric
S. aureus	2	10	Healthcare worker	Laboratory
S. aureus	2	10	Healthcare worker	Medical
S. aureus	2	10	Inpatient	NICU
S. aureus	2	10	Inpatient	NICU
S. aureus	1	11	Inpatient	Medical
S. aureus	1	11	Inpatient	NICU

children has been attributed to frequent contact with respiratory secretions particularly in the early stages of life where careful handling of such secretions is problematic. *S. aureus* carriage rate was least among participants older than 30 years, possibly due to improved personal hygiene and well established immune system.

Nine out of the 27 *S. aureus* isolates were MRSA, representing 33.3% of the isolates, and indicating approximately one out of every three *S. aureus* carriers harbor's MRSA. However, the prevalence of MRSA in the sampled population was 8.5% (9/106), suggesting about nine in every 100 persons are carriers of MRSA. MRSA rates of 2.5%, 7%, and 9% have been reported in burn centres in the United States of America, Iran and the United Kingdom respectively [22,23]. However, the present rate of MRSA noted is relatively lower than 16.5% reported in Nigeria [24]. Only inpatients and healthcare workers were colonized, and colonization was spread among the various wards/units and dominant in the NICU, but no case was recorded in the Medical ward. Studies have shown persons who have been recently hospitalized, close contact with a person who has been hospitalized and those previously on antimicrobial-drug therapy are at a greater risk of acquiring MRSA [25]. Even though there was no case of MRSA among caregivers, frequent contact with their patients put them at risk.

The isolates were highly resistant to most of the first line antibiotics commonly used in treatment. Resistance were relatively higher to erythromycin, amoxicillin and tetracycline, an observation which agrees with a report by CDC [26]. There are reports on *S. aureus* resistance, particularly MRSA to some higher generations of cephalosporin [26]. The low resistance seen in azithromycin, sparfloxacin, lincomycin, levofloxacin, ciprofloxacillin, gentamycin and roxithromycin may be due to the fact that they are not commonly prescribed or used in the hospital. Additionally, we noted relatively high resistance in MRSA isolates compared to their non-MRSA counterparts. This observation has been reported to be associated with high treatment cost, longer hospitalization period, and treatment difficulties or failure [27]. Generally, antibiotic resistance is expected to be high in settings where antibiotic regulations barely exist or are less enforced.

Conclusion

The results from this study showed that 25.5% (27/106) of the population carry *S. aureus* in their nares, and 8.5% (9/106) harbor MRSA while approximately 17.0% (18/106) are non-MRSA. *S. aureus* carriage rate was highest among neonates (42.1%) follow by age group 11–20 years (36.8%). Health care workers had a rate 27.8% whiles NICU as a ward/Unit had the highest carriage rate of 28.6%. This study indicates relatively high nasal carriage rate of MRSA (33.3%), and healthcare workers had the highest proportion of carriers (40%), followed by inpatients (33.3%), while no MRSA was isolated from caretakers. Generally, antibiotics resistance was higher in MRSA isolate than non-MRSA. An expanded study is recommended to identify risk factors for *S. aureus* associated nosocomial infections in the various units/wards of the TTH.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

CRediT authorship contribution statement

Williams Walana: Data curation, Formal analysis, Writing - original draft. **Bernard Posotoso Bobzah:** Data curation, Formal analysis. **Eugene Dogkotenge Kuugbee:** Data curation. **Vicar Kofi Ezekiel:** Data curation. **Iddrisu Baba Yabasin:** Formal analysis. **Alhassan Abdul-Mumin:** Formal analysis. **Juventus Benogle Ziem:** Writing - review & editing.

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