RESEARCH NOTE

Nasal carriage, risk factors and antimicrobial susceptibility pattern of methicillin resistant Staphylococcus aureus among healthcare workers in Adigrat and Wukro hospitals, Tigray, Northern Ethiopia

Haftom Legese1,2*, Atsebaha Gebrekidan Kahsay1, Amlisha Kahsay1, Tadele Araya1, Gebre Adhanom1,2, Saravanan Muthupandian1 and Araya Gebreyesus1

Abstract

Objective: The aim of this study was to determine nasal carriage, risk factors and antimicrobial susceptibility pattern of methicillin resistant Staphylococcus aureus among health care-workers of Adigrat and Wukro hospitals Northern Ethiopia.

Results: The overall prevalence of S. aureus and methicillin resistance S. aureus (MRSA) in the present study were 12% (29/242) and 5.8% (14/242) respectively. The rate of MRSA among S. aureus was 48.3%(14/29). In this study, MRSA carriage was particularly higher among nurse professionals (7.8%) and surgical ward (17.1%). None of the MRSA isolates were sensitive to penicillin and ampicillin. However, low resistance was found for chloramphenicol and clindamycin. Being diabetic and use of hands rub was statistically significant with MRSA colonization.

Keywords: Antimicrobial susceptibility test, Health care workers, methicillin resistance Staphylococcus aureus, nasal carriage, Staphylococcus aureus

Introduction

Staphylococcus aureus is known to be the cause of hospital and community acquired infections [1]. Methicillin resistant S. aureus (MRSA) causes a significant problem of the world and major health care associated pathogen [2, 3]. About 10–35% world population harbors MRSA in their anterior nares [4]. The emergence of MRSA is an important hospital acquired pathogen continues to remain a significant factor for failure of patient management worldwide [3–5].

Increasing rates of antibiotic resistance owing to an incautious use of antimicrobials lead to decrease treatment options for MRSA infection [6]. The increasing of MRSA strains becomes a public health problem [3]. This has a negative effect on the treatment cost, long hospitalization, and increased morbidity and mortality especially among the critically ill patients [7]. The problem of MRSA is observed all over the world, although, the burden of infection is high in developing countries [8].

High MRSA carriages of health care professionals have been reported as the key mechanism of transmission among patients during treatments, patients contact and aerosolization following sneezing [9]. Health care workers who have direct contact between the community and hospital may serve as the agents of the cross-transmission of the community acquired and hospital acquired MRSA [10].

Knowledge of MRSA prevalence and recent antimicrobial susceptibility pattern is very important for appropriate selection of the antimicrobial agents [11]. However, in
most hospitals of African countries, there is neither surveillance system nor control policy for MRSA, this plays significant role for increasing the problem [12].

Therefore, this current study was aimed to determine nasal carriage, antimicrobial susceptibility patterns and associated factors of MRSA colonization among healthcare workers in Adigrat and Wukro hospitals, Tigray, northern Ethiopia. This evidence based information in the study area will contribute a role for the prevention and control of MRSA by responsible bodies.

**Main text**

**Methods**

**Study area and study design**

This study was carried out in Wukro and Adigrat general hospitals. Those hospitals are found in eastern zone of Tigray region and are located about 824 and 900 km respectively north of Addis Ababa (Capital city of Ethiopia). Wukro and Adigrat general hospitals have a total staffs 313 among those 41.3% are males and 58.7% are female, and are serve for the total population of 755,343. A cross sectional study was carried out among 242 health care workers from September to December 2016.

**Isolation and identification**

Swabs were inoculated on Manitol Salt agar (MSA) (Oxid, UK) and incubated at 37 °C for 24 h and sub cultured into blood agar. All positive culture was identified by their characteristics appearance and biochemical test using standard procedure. Colonies that were Manitol fermented (golden yellow colonies), β-hemolytic on blood agar were considered as *S. aureus* and was confirmed by Coagulase test as positive [13].

**Antimicrobial susceptibility testing**

Antimicrobial susceptibility testing was performed using modified Kirby–Bauer disc diffusion method on Muller–Hinton agar (MHA; Oxoid, UK) according Clinical and Laboratory Standards Institute (CLSI, 2016) guidelines [14]. From overnight grown colonies on nutrient agar 3–5 well-isolated colonies were emulsified in 3–4 ml of sterile physiological saline to get bacterial inoculums equivalent to 0.5 McFarland turbidity standards. After that the antibiotic discs were placed manually on the medium and incubated at 37 °C for about 18 h and the zones of inhibition was measured using caliper. The interpretation of the results was made based on the CLSI criteria as sensitive, intermediate and resistant [14]. Cefoxitin discs (30 µg), penicillin (10 µg), ampicillin (10 µg), erythromycin (15 µg), cotrimoxazol (25 µg), chloramphenicol (30 µg), gentamycin (10 µg), kanamycin (30 µg), amikacin (30 µg), ciprofloxacin (5 µg), tetracycline (30 µg), and clindamycin (2 µg) (Oxoid, UK). All isolates resistant to cefoxitin was considered as MRSA [14].

**Data processing and analysis**

The findings were statically analyzed using descriptive statistics, Chi square test (χ²) and p < 0.05 was considered as statistically significant. The variables from the demographic and associated risk analysis were performed using SPSS (version 22) package.

**Results**

**Socio-demographic characteristics**

A total of 242 health professionals were included in the study. The age of study participants ranged from 20 to 59 years with mean age of 31.78 ± 8.9 years. One hundred forty-two (58.7%) were females and 100 (41.3%) were males. The mean number of their work experience was 9.1 years.

**Prevalence of *Staphylococcus aureus* and MRSA**

The prevalence of *S. aureus* and MRSA in this study was 12% (29/242) and 5.8% (14/242) respectively. The prevalence of MRSA among nurse, doctor and midwife professionals were 10 (7.8%), 1 (7.7%), and 2 (6.7%) respectively. The highest rate of *S. aureus* and MRSA observed in surgical ward were 7 (20.0%) and 6 (17.1%) respectively (Additional file 1: Table S1).

**Risk factors associated for MRSA colonization**

Chi square test (χ²) showed that use of hand rub (p < 0.001), and being a diabetic (p < 0.001), were statistically significant with MRSA colonization (Table 1).

**Antimicrobial susceptibility patterns of *Staphylococcus aureus***

The antimicrobial Susceptibility patterns were performed for the 29 *S. aureus* isolates against 12 antimicrobials. Of the 29 isolates, 93.1% showed resistance to penicillin followed by kanamycin 19 (65.5%), erythromycin 18 (62.1%), tetracycline 16 (55.2%) cotrimoxazole 15 (51.7%), ampicillin 14 (48.3%), and amikacin 13 (44.8%). Low resistance were found for chloramphenicol 5 (17.2%) and clindamycin 5 (17.2%). None of the isolates were intermediate resistance (Fig. 1).

**Multidrug resistance of *Staphylococcus aureus***

According to Magiorakos et al. [15], multi-drug resistance in this study was considered as resistance to three or more of the antimicrobial class tested. Twenty-two (75.9%) of all the isolates were multi-drug resistant,
five isolates were resistant for three and two isolates were resistant for ten antimicrobials (Table 2).

Discussion
The overall nasal carriage of S. aureus in the present study was 12%. This is supported by study carried out in India (14%) [10]. However, lower than that of reported from Ethiopia, (28.8%) [13], Democratic Republic Congo (16.5%) [16], Gaza Strip (31.1%) [17] Pakistan (48%) [18], China (25.3%) [19] and Iran (25.7%) [20].

The total prevalence of MRSA in this study was 5.78%. This was similar with results from [8], France (5.3%) [21], Asia (6.1%) [8] and Iran (5.3%) [20]. However, it was lower compared with the study revealed in Ethiopia, Mekelle (14.1%) [22] and Dessie (12.7%) [13], Egypt (20%) [23], Nigeria (39.9%) [12], Gaza Strip (25.5%) [17] and Pakistan (13.95%) [18]. On the other hand, our result was higher than study reported from and China (1.0%) [19]. This variations of prevalence among different study areas might be due to difference in rate of patient admission, study period [22], microbiological methods (from sample size to culture media) antimicrobial policy, in addition to that, variety levels of commitment to infection prevention measure among hospitals, and awareness of the health care worker about MRSA may contribute to the difference.

In current study, MRSA carriage was relatively higher among nurses (7.8%) followed by doctors (7.7%). This is consistent with study conducted in Ethiopia, Dessie [13], Gaza Strip [17] and India [10]. MRSA carriage was particularly high among surgical ward (17.1%) this result is comparable with corresponding study in Gaza Strip (35%) [17] and Dessie (35%) [13]. This result might be explained by the frequent direct physical contact of doctors and nurses with patients and increase workload in surgical wards.

In this study, use of hands was statistically significant with MRSA colonization. Health care workers rarely used hand rub were high proportion to have MRSA colonization on their anterior nare than those who were used hand rub usually and always. This finding is in line to previous studies in America [7], France [21], and Taiwan [24]. The temporary hand carriage of bacteria on the hands of health professionals could account for the major mechanism for the auto-transmission from contaminated hand to nose.

The present study, found that being diabetic patients was statistically associated with MRSA colonization. Health care workers with diabetic were high proportion to have MRSA colonization on their anterior nare. This

Table 1 Risk factors associated with MRSA colonization among health professionals at Adigrat and Wukro hospitals, Tigray, Northern Ethiopia September–December 2016

| Variable                          | MRSA                  | p value |
|-----------------------------------|-----------------------|---------|
| No, n (%)                         | Yes, n (%)            |         |
| Sex                               |                       |         |
| Male                              | 93 (93)               | 7 (7.0) | 0.497   |
| Female                            | 135 (95.1)            | 7 (4.9) |         |
| Age group                         |                       |         |
| 20–29                             | 129 (94.2)            | 8 (5.8) | 0.503   |
| 30–39                             | 52 (91.2)             | 5 (8.8) |         |
| 40–49                             | 30 (96.8)             | 1 (3.2) |         |
| 50–59                             | 17 (100)              | 0 (0.0) |         |
| Work experience                   |                       |         |
| < 5                               | 110 (94)              | 7 (6.0) | 0.486   |
| 6–10                              | 56 (96.6)             | 2 (3.4) |         |
| 11–20                             | 22 (88)               | 3 (12.0)|         |
| 21–30                             | 40 (95.2)             | 2 (4.8) |         |
| Department                        |                       |         |
| Medical                           | 26 (96.3)             | 1 (3.7) | 0.081   |
| Surgical                          | 29 (82.9)             | 6 (17.1)|         |
| Pediatric                         | 20 (90.9)             | 2 (9.1) |         |
| Gynecology and obstetrics         | 28 (93.3)             | 2 (6.7) |         |
| Laboratory                        | 25 (100)              | 0 (0.0) |         |
| Outpatient department             | 48 (96)               | 2 (4.0) |         |
| Pharmacy                          | 25 (96.2)             | 1 (3.8) |         |
| Others                            | 27 (100)              | 0 (0.0) |         |
| Hand washing habit                |                       |         |
| Always                            | 116 (94.3)            | 7 (5.7) | 0.298   |
| Usually                           | 91 (95.8)             | 4 (4.2) |         |
| Rare                              | 21 (87.5)             | 3 (12.5)|         |
| Use of hand rub                   |                       |         |
| Always                            | 123 (99.2)            | 1 (0.8) | 0.001*  |
| Usually                           | 97 (95.1)             | 5 (4.9) |         |
| Rare                              | 8 (50)                | 8 (50)  |         |
| Prior hospitalization             |                       |         |
| Yes                               | 23 (88.5)             | 3 (11.5)| 0.183   |
| No                                | 205 (94.9)            | 11 (5.1)|         |
| History of antibiotics treatment  |                       |         |
| Yes                               | 115 (92)              | 10 (8)  | 0.127   |
| No                                | 113 (96.6)            | 4 (3.4) |         |
| Chronic obstructive pulmonary disease |                   |         |
| Yes                               | 28 (87.5)             | 4 (12.5)| 0.081   |
| No                                | 200 (95.2)            | 10 (4.8)|         |
| Diabetic mellitus                 |                       |         |
| Yes                               | 7 (70)                | 3 (30.0)| 0.001*  |
| No                                | 221 (95.3)            | 11 (4.7)|         |

*Statistically significant with MRSA colonization
NB: use of hand rub is use of a waterless alcohol [30]
was in line with studies from Tanzania [25] Iran [20], and Taiwan [26]. This may be due to diabetic patients reduced immunity which fails to combat the pathogens [25].

In the current study, there was no statistically significant of MRSA with educational status, hand washing habit, prior hospitalization, history of antibiotic treatment, and presence of chronic obstructive pulmonary disease in this study. This was in agreement with a result obtained in Ethiopia [13] and other studies conducted in other parts of the world [8, 20, 27].

Concerning antimicrobial susceptibility patterns of MRSA isolates, clindamycin and chloramphenicol were effective against MRSA isolates. However, increasing resistance was observed in our finding which is consistent with study reported from Pakistan ampicillin, penicillin, erythromycin, amikacin and ciprofloxacin (100%), (100%), (66%), (44%), and (33%) respectively [18]. Cotrimoxazole also showed a similar result compared with corresponding reports of Dessie (66.7%) [11]. Despite slight differences in the reported figures, the susceptibility patterns of antimicrobial were in line with the study from Nigeria for gentamycin 50 (63.3%), erythromycin 55 (69.6%) and Ciprofloxacin 32 (40.5%) [12], in India [3] for ciprofloxacin (34.6%) and erythromycin (54.8%), chloramphenicol (16.1%) from Serbia [27], and penicillin (93%) reported from India [10].

Higher susceptibility was also showed in the present study as compared to a result from health care workers at Iran for gentamycin (69%), clindamycin (69%), and ciprofloxacin (66%) [20]. Kanamycin also showed lower resistance compared with similar study in Serbia.

**Table 2** Multi-drug resistance nature of *S. aureus* isolates at Adigrat and Wukro hospitals, Tigray, Northern Ethiopia September–December 2016

| Antibiotics | Number (%) |
|-------------|------------|
| For three PEN, AMP, CXT | 2 (9.2%) |
| PEN, ERY, TTC | 1 (4.54%) |
| PEN, ERY, AK | 1 (4.54%) |
| PEN, TTC, AK | 1 (4.54%) |
| For four PEN, ERY, TTC, AK | 1 (4.54%) |
| PEN, AMP, TTC, CXT | 1 (4.54%) |
| PEN, AMP, TTC, AK | 1 (4.54%) |
| For six PEN, DA, TS, CIP, TTC, AK | 1 (4.54%) |
| PEN, GM, TS, CIP, TTC, AK | 1 (4.54%) |
| PEN, AMP, TS, TTC, AK | 1 (4.54%) |
| For seven PEN, DA, ERY, GM, TS, CIP, CHL | 1 (4.54%) |
| PEN, AMP, ERY, GM, TS, CIP, CXT | 1 (4.54%) |
| For eight PEN, ERY, GM, TS, CIP, CHL, TTC, AK | 1 (4.54%) |
| PEN, AMP, ERY, GM, TS, CIP, TTC, CXT | 1 (4.54%) |
| PEN, AMP, ERY, GM, TS, CHL, AK, CXT | 1 (4.54%) |
| PEN, AMP, ERY, GM, TS, CIP, TTC, AK, CXT | 1 (4.54%) |
| For nine PEN, AMP, ERY, GM, TS, TTC, AK, CXT | 1 (4.54%) |
| PEN, AMP, ERY, GM, TS, CIP, AK | 1 (4.54%) |
| For ten PEN, AMP, DA, ERY, GM, TS, CIP, CHL, TTC, AK, CXT | 1 (4.54%) |
| PEN, AMP, DA, ERY, GM, TS, CIP, CHL, TTC, AK | 1 (4.54%) |
| Total | 22 (100%) |

*PEN* penicillin, *AMP* ampicillin, *GM* gentamycin, *AK* amikacin, *CHL* chloramphenicol, *CIP* ciprofloxacin, *TTC* tetracycline, *TS* cotrimoxazol, *DA* clindamycin, *ERY* erythromycin, *K* kanamycin, *CXT* cefoxitin

**MDR** multidrug resistant; **MDR** definition for *S. aureus* percent is computed from total number of *S. aureus*
control strategies of the hospital settings. In this study high prevalence of multi drug resistance towards S. aureus was observed. Of the total isolates 22 (75.9%) were resistant to three and above class of antimicrobials [15]. Fourteen of them (63.6%) were MRSA and comparable susceptibility was observed in a study from Ethiopia, Dessie [11]. This increased multi drug resistance might be due to continuous genetic variation of strains by mutation, or cross transmission of the a resistance genetic elements from one to another bac
terium, overcrowded wards, and prescribed of antibiotics without culture and sensitivity [18].

Conclusions
The present study, the overall prevalence of MRSA in the study area was found to be 5.78%. The carriage rate MRSA was worse among nurses and working in surgical wards. Rarely used hand rub and being diabetics were statistically significant with MRSA colonization. Clindamycin and chloramphenicol were sensitive antimicrobials for the treatment of MRSA and S. aureus. The majority of the S. aureus isolates were multidrug resistant.

Limitation of the study
The infection is due to community or hospital acquired strains could not be identified. More sensitive and specific molecular techniques could not be used to identify the species and strain typing of S. aureus.

Furthermore, for the future researcher phenotypic and genotypic studies are needed to establish and clarify the genetic mechanism behind susceptibilities to antibiotics.

Additional files

Additional file 1: Table S1. Prevalence of S. aureus and MRSA among health professionals in Adigrat and Wukro hospitals, Tigray, Northern Ethiopia September–December 2016.

Additional file 2: Figure S1. Antimicrobial Susceptibility pattern of Methicillin Resistant Staphylococcus aureus strains to other antibiotics tested at Adigrat and Wukro hospitals, Tigray, Northern Ethiopia September–December 2016 (n = 14).

Additional file 3: Table S2. Antimicrobial susceptibility pattern of MRSA and MSSA isolates from health professionals at Adigrat and Wukro hospitals, Tigray, Northern Ethiopia September–December 2016.

Abbreviations
AST: antimicrobial susceptibility testing; CLSI: Clinical and Laboratory Standards Institute; MDR: multi-drug resistance; MRSA: methicillin resistant Staphylococcus aureus; MSSA: methicillin sensitive Staphylococcus aureus.

Authors’ contributions
HL designed the study, collection, analysis, and interpretation of data, and drafted the manuscript. AG, AGK, and AK designed the study, supervised data collection both on field and in laboratory, and prepared the manuscript. All authors read and approved the final manuscript.

Author details
1 Department of Microbiology and Immunology, Institute of Biomedical Sciences, College of Health Science, Mekelle University, Mekelle, Ethiopia.
2 Department of Medical Laboratory, College of Medicine and Health Science, Adigrat University, Adigrat, Ethiopia.

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Competing interests
The authors declare that they have no competing interests.

Availability of data and materials
All data collected and analyzed during this study were included in the manuscript. But if the full paper is needed, it will be shared upon request by the editor from the corresponding author.

Consent for publication
Not applicable.
Ethics approval and consent to participate
The study was approved by College of health sciences Research ethical review committee of Mekelle University, Ethiopia (Consent Ref Number 0814/2016 approval dated 16/08/2016. Official letter was obtained from Tigray regional health bureau to Adigrat and Wukro hospitals (Consent Ref Number 01/1418/2016 approval dated 10/09/2016. Permission was also obtained from administrative of each hospital and other concerns. Written informed consent was sought from each study participants before sample collection and maintained throughout the study. All participants were given code numbers to keep their identity confidential.

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