Infection and Drug Resistance

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Nasal Carriage Rate of *Staphylococcus aureus*, Its Associated Factors, and Antimicrobial Susceptibility Pattern Among Health Care Workers in Public Hospitals, Harar, Eastern Ethiopia

Wondimagegn Wolde[1], Habtamu Mitiku[2], Rajesh Sarkar[1], Tadesse Shume[1]

[1]Department of Medical Microbiology and Immunology, College of Health and Medical Science, Haramaya University, Harar, Ethiopia; [2]Department of Tropical and Infectious Disease and Parasitology, College of Health and Medical Science, Haramaya University, Harar, Ethiopia

Correspondence: Tadesse Shume, Haramaya University, College of Health and Medicine Sciences, Department of Medical Microbiology and Immunology, P.O. Box- 235, Harar, Ethiopia, Email tadeshume15@gmail.com

Background: *Staphylococcus aureus* is the bacteria that colonizes the nasal nares of health-care workers and serves as a reservoir for the spread of pathogen for subsequent infections, mainly Methicillin-resistant *Staphylococcus aureus*. However, there is a limited study conducted regarding this topic in Harar, Eastern Ethiopia.

Objective: The main objective of this study was to determine the prevalence of nasal carriage of *Staphylococcus aureus*, associated factors and antimicrobial susceptibility patterns among health-care workers of public hospitals in Harar, Eastern Ethiopia from May 15 to July 30, 2021.

Methods: A hospital-based cross-sectional study was conducted on 295 health-care workers. A simple random sampling technique was used to select the participant. Nasal swabs were collected and cultured at 35°C for 24hrs. *S. aureus* was identified using the coagulase test and catalase test. Methicillin resistance *S. aureus* (MRSA) was screened using a cefoxitin disc on Muller Hinton agar using the Kirby-Bauer disc diffusion method. Data were entered into EPI-Info version-7 and transferred to SPSS-20 for analysis. Factors associated with nasal carriage of *Staphylococcus aureus* were determined by using chi-square analysis. A *p*-value of less than 0.05 was considered statistically significant.

Results: The prevalence of *Staphylococcus aureus* in this study was 15.6% (95% CI: 11.7%, 20.3%) and methicillin-resistant *Staphylococcus aureus* was 11.2% (95% CI: 7.8%, 15.4%), respectively. Age ($P < 0.001$), work experience ($p < 0.001$), working unit ($p < 0.02$), antibiotic use within 3 months ($p < 0.001$), hand washing habit ($p < 0.01$), hand rub use ($p < 0.001$), living with smokers ($p < 0.001$), living with pets ($p < 0.001$) and having chronic diseases ($p < 0.001$) were found significantly associated with *Staphylococcus aureus* nasal carriage.

Conclusion: The prevalence of *Staphylococcus aureus* and Methicillin-resistant *Staphylococcus aureus* are high in our study. The study emphasizes the need for regular surveillance among hospital staff and the environment to prevent MRSA transmission among health-care personnel.

Keywords: MRSA, nasal carriage, health care workers

Introduction

Staphylococcus aureus is a clinically significant pathogen that commonly causes community-acquired and nosocomial infections, especially in the hospital setting and is the most important risk factor for transmitting this pathogen.[1,2] The largest ecological reservoir of human strains of *S. aureus* is the human nose; however, the skin, hair, and mucous membranes may also be colonized. These resident bacteria do not normally cause disease but nasal carriage plays a key role in the development of acute and chronic infections.[3,4]

In particular, the various manifestations of methicillin-resistant *S. aureus* (MRSA), are responsible for drastically lowered therapeutic options, serious courses of infection, and dramatically increased costs for prevention measures.[5]

Received: 7 November 2022
Accepted: 25 May 2023
Published: 2 June 2023

Over the last few years, MRSA has emerged and become one of the leading causes of bacterial infections in both healthcare and community settings.[6]

Therefore, the colonization of health-care workers with *S. aureus*, especially MRSA, is considered one of the important risk factors for nosocomial infection.[7,8] Multidrug resistance of nasal *S. aureus* associated with methicillin-resistant strains is of great public health concern, especially in developing countries.[9] Accurate and early determination of methicillin resistance is very important in the prognosis of infections.[10]

However, there is limited information regarding the prevalence of *S. aureus* and factors predisposing to nasal colonization among health-care workers. Thus, this study aimed to determine the prevalence, associated factors and antimicrobial susceptibility patterns of *S. aureus* among health-care workers working in public Hospitals, Harar, Eastern Ethiopia.

Materials and Methods

Study Area and Period

The study was conducted at two public hospitals (Hiwot Fana Specialized University Hospital and Jugol Hospitals) in Harar, Eastern Ethiopia, from May 15 to July 30, 2021. Hiwot Fana Specialized University Hospital (HFSUH) and Jugol Hospital are the largest hospitals in the city that provide health-care services to more than 140,000 patients per year.

Study Design and Populations

A cross-sectional study was conducted. Health-care workers working in HFSUH and Jugol Hospitals were the study population. Health-care workers working at different departments and who were volunteers to give nasal specimens in selected hospitals were included. While those who were unable to give nasal swab specimens due to nasal abnormalities or those who did not volunteer to give a nasal specimen and who were on antibiotic therapy in the last two weeks[11] were excluded from the study.

Sample Size Determination and Sampling Technique

The sample size was determined by a single population proportion formula using the prevalence of nasal carriage of MRSA from a study conducted in Dessie referral Hospital (12.7%),[12] with a margin of error of 0.04 and a Z score for 95% confidence interval of 1.96, and finally, a 10% non-response rate was added. The final sample size was 295. A simple random sampling technique was used after allocation to two hospitals and professions proportionally. The participants were recruited by using a lottery method.

Data Collection Instruments and Procedures

A structured questionnaire was used to collect data. The questionnaire contains two parts: the first was socio-demographic variables like age, gender, level of education, number of people living with, income, department, occupational group, and work experience at the hospitals, and the second part contains possible risk factors associated with the colonization of *S. aureus* including MRSA like hand washing or the use of hand rub habit, hospitalization within the last three months, having of chronic disease, having respiratory disease, use of antibiotic within the last three months, proper adherence of antibiotic therapy, cigarette smoking habit, and status of passive smoking, living with pet and/or farm animals.

Specimen Collection and Transportation

After the informed consent has been signed and self-administered questionnaires were completed, nasal swab specimens were collected by using sterile cotton tip swabs pre-wetted with sterile saline for each anterior nares from each study participant. Immediately, nasal swabs were inoculated in a properly labelled sterile Tryptic soya broth (Oxoid Ltd. England) and transported using an ice box to keep the cold chain until it reached Haramaya University's Microbiology Laboratory for investigation.

Laboratory Isolation and Identification

The collected samples were inoculated onto Mannitol Salt Agar (MSA) (Oxoid Ltd. England). To confirm the fermentation of Mannitol, the growth of golden yellow colonies on MSA (Oxoid, Cambridge, UK) surrounded by yellow zones after 24 hours of incubation at 37°C indicated a positive result for *S. aureus*. These isolates were sub-cultured onto Blood Agar Plate, and incubated at 37°C for 24hrs. Colony morphology, Gram stain reaction, and biochemical tests such as catalase and coagulase test were performed to confirm *S. aureus*.[13]

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility test was done according to the Clinical and Laboratory Standards Institute guidelines (CLSI), using the Kirby-Bauer disc diffusion method.[14] Suspension of confirmed isolates was done using normal saline (0.85% NaCl) and was incubated at 37°C for at least 15 minutes and the turbidity was adjusted to match that of 0.5 McFarland standards. A sterile swab was dipped into the suspension, applied to the concentrated evenly distributed on Muller Hinton agar and left at room temperature to dry for 3 to 5 min. Then, selected antimicrobial drug discs such as chloramphenicol (5 µg), gentamicin (10 µg), clindamycin (2 µg), cefoxitin (30 µg), erythromycin (15 µg), cotrimoxazole (25 µg), ciprofloxacin (30 µg), penicillin (10 µg) and tetracycline (30 µg) (Oxoid, LTD, UK) were manually placed at a distance of 15mm from each other on to the Muller Hinton agar and incubated at 37°C for 18–24 h. After the incubation, the diameter of the inhibition zone was measured using a scaled ruler (Caliper) to the nearest millimeters and compared against the predefined values provided by CLSI guidelines. The growth inhibition zone was interpreted as susceptible, intermediate or resistant after comparison with clinical and laboratory standard guidelines.[15]

Testing for MRSA

An MRSA was screened with 30µg of cefoxitin via Mueller-Hinton agar. The zone of inhibition was determined after 24 hours of incubation at 33–35°C. All isolates ≤24 mm of cefoxitin, were considered MRSA.[15]

Quality Control

The questionnaire was pretested at Bisidimo General Hospital. Data collectors were trained and investigators were also following the standard procedures to collect and investigate the specimen. Double data entry was done using Epi-Data to minimize errors during data entry. All culture media were prepared by following the manufacturer's instructions, and sterility was checked by incubating 5% of each batch of the prepared culture media at 37°C overnight and checked for growth of contaminants. *Staphylococcus aureus* ATCC 25923 and *Escherichia coli* (ATCC 25922) were used for positive and negative control for laboratory investigations.

Data Analysis

Data was entered using Epi-Data (version 3.1) and transferred to SPSS (version 20) package for analysis. The characteristics of the study population were summarized using descriptive statistics, frequency and percentage. The Chi-square test was used to test the difference between independent and outcome variables. Variables with a p-value <0.05 were considered statistically significant.

Results

Socio-Demographic Characteristics

Amongst 295 participants, 191 (64.7%) were from HFSUH and the remaining 104 (35.3%) were from Jugol Hospital. From this study, 154 (52.2%) were females. The mean age of the participants was 22.8 years with a standard deviation (SD) ± 1.37 years. The majority 242 (82%) had a family size of fewer than five members (Table 1).

Behavioural and Medical Clinical Factors

In the present study, 25 (8.5%), 44 (14.9%), 33 (11.1%), 10 (3.4%), 20 (6.8%), 58 (19.7%) of participants responded that they had been hospitalized within the last three months, diseased with respiratory infection within the last three months,

Table 1 Socio-Demographic Characteristics of the Health Professionals in HFSUH and Hospitals, Harar, Eastern Ethiopia, 2021

Characteristics	Category	Frequency (%)
Gender	Male	141 (47.8%)
	Female	154 (52.2%)
Age (years)	20–30	211 (71.5%)
	31–40	51 (17.3%)
	≥40	33 (11.2%)
Educational level	Certificate/Diploma	47 (15.9%)
	Bachelor/ First Degree	214 (72.6%)
	Speciality	34 (11.5%)
Professional category	Physicians	99 (33.6%)
	Nurses	124 (42%)
	Laboratory	23 (7.8%)
	Midwives	17 (5.8%)
	Pharmacy	18 (6.1%)
	Radiology	4 (1.4%)
	Others	10 (3.3%)
Work experience	≤5	231 (78.3%)
	>5	64 (21.7%)
Monthly income	≤5000	34 (11.5%)
	>5000	261 (88.1%)
Family size	≤3	193 (65.1%)
	>3	109 (36.9%)

had chronic medical conditions, smoking a cigarette, live with another person who smokes and contacted with pet and farm animals, respectively. Meanwhile, 76 (25.8%) participants had used antibiotics within the last three months, of which, 16 (5.4%) had not properly adhered to their antibiotic therapy. Regarding hand washing habits, 153 (51.8%) of respondents wash their hands always and 142 (48.2%) wash their hands usually. In addition, 129 (43.3%) use hand rub frequently and 142 (48.1%) use hand rub usually.

The Prevalence of *S. aureus* and MRSA

The prevalence of *S. aureus* and MRSA in this study was 15.6% (46/295; 95% CI: 11.7%, 20.3%) and 11.2% (33/295; 95% CI: 7.8%, 15.4%), respectively. The MRSA carriage rate was highest among nurses 15.3% (19/124) followed by doctors, 11.1% (11/99). Besides, the highest prevalence of nasal carriage of *S. aureus* and MRSA in the surgical wards was 18 (36.7%) and 15 (30.6%), respectively (Table 2).

Factors Associated with MRSA Nasal Carriage

The study showed that there was no significant difference between nasal carriage of MRSA with sex (p = 0.77), level of education (p = 0.29), occupation (p = 0.36), and monthly income (p = 0.45). However, age (P = 0.001) was highly significant, year of service (p = 0.005) was very significant, and department (p = 0.001) were highly significantly associated with MRSA nasal colonization (Table 2).

Regarding behavioural and clinical factors, there was a significant difference between nasal carriage of MRSA with experience/contact with smokers, pet or farm animals, antibiotic usage within the last three months and having a chronic disease (P = 0.001). In addition, this study showed that there was an association of MRSA carriage with hand washing habits (p = 0.01) and utilization of hand rub (p = 0.001). However, no significant differences were seen in smoking cigarettes, having a respiratory infection and hospitalization within the last three months with a p-value of (p = 0.69), (p = 0.20), and (p = 0.13), respectively (Table 3).

Table 2 Association of Socio-Demographic Factors with MRSA Status of Health Professionals in HFSUH and Jugol Hospitals, Harar, Eastern Ethiopia, 2021

Variables	Categories	*S. aureus* (%)	MRSA Status		χ^2-Square Value	*P*-value
			Yes (%)	No (%)		
Gender	Male	25	15 (10.6)	10 (89.4)		0.77
	Female	21	18 (11.7)	3 (88.3)	0.82	
Age	≤30	19	2 (0.9)	17 (99.1)		0.001*
	>30	27	9 (36.9)	17 (61.3)	78.2	
Work experience	≤5	17	11 (13.4)	6 (86.6)		0.005*
	>5	29	22 (37.5)	7 (62.5)	87.2	
Educational level	Certificate/Diploma®	3	3 (100)	–		0.290
	Bachelor/ First Degree	35	25 (11.6)	10 (88.4)	3.3	
	Speciality and MSc	8	5 (14.7)	3 (85.3)		
Professional category	Physicians	15	11 (11.1)	4 (88.9)		0.366
	Nurses	26	19 (15.3)	7 (84.7)	2.0	
	Others	5	3 (4.2)	2 (95.8)		
Monthly income (ETB)	≤ 5000	6	3 (8.8)	3 (91.2)		0.45
	>5000	40	30 (11.5)	10 (88.5)	0.2	
Working Unit/Department	Medical	6	6 (100)	–		0.001*
	Surgical	11	4 (36.4)	7 (63.6)	27.3	
	Others	29	12 (7.2)	17 (92.8)		

Note: *Statistical significance.

Antimicrobial Susceptibility Patterns of *S. aureus*

The antimicrobial susceptibility patterns were performed for the *S. aureus* isolates against 9 antimicrobials. Of the 46 (15.6%) isolates, chloramphenicol (100%), gentamicin (95.7%), ciprofloxacin (95.7%) and clindamycin (93.5%) were found to be the most effective drugs against *S. aureus*. However, about 93.3% of isolates showed resistance to penicillin followed by tetracycline (27, 58.7%). Among all *S. aureus* isolates, 33 (71.7%) were resistant to cefoxitin, considered an MRSA (Figure 1). Out of 33 MRSA isolates, all (100.0%) were resistant to penicillin.

Discussion

According to our data, the *S. aureus* isolation rate from the 295 samples was 46 (15.6%). This was similar to results reported from Atlanta GA (16.7%),[16] the Democratic Republic of Congo (16.5%),[17] and Nepal (15.7%).[18] However, comparatively higher values have been reported in other settings like Pakistan (48%),[19] and India (43.6%).[20] The reported proportion is significantly not lower than previously reported values in Libya (48.5%),[21] and Tanzania (41.4%).[6]

The total prevalence of MRSA in this study was 11.2% (95% CI: 7.8%, 15.4%). This coincides with results reported from studies carried out in Nigeria (13.5%)[22] and India (12%),[20] Ethiopia (12.7%).[12] However, our result was higher than the study reported from Nepal (3.4%),[18] Ethiopia (5.7%),[23] and Odisha (7.5%).[24] On the other hand, it was lower compared with the study revealed in Assam (25%),[25] Libya (21.4%),[21] Saudi Arabia (18%),[26] Uganda (48%),[27] Tanzania (15.6%).[6] Numerous factors may explain these variations of prevalence among one-of-a-kind look at regions, the most critical of which encompass; the difference within the rate of patient admission, study period, limited infrastructure, adding to this, various levels of commitment to infection prevention measures amongst hospitals and study duration

Table 3 Association of MRSA Status with Behavioural and Medical (Clinical) Factors in Health Professionals in HFSUH and Jugol Hospitals, Harar, Eastern Ethiopia, 2021

Characteristics	Category	MRSA Status		χ^2-Square Value	*p*-value
		Yes (%)	No (%)		
Hospitalized within three months	Yes	5 (20)	20 (80)		0.13
	No	28 (10.4)	242 (89.6)	2.1	
Had respiratory infection	Yes	7 (16)	37 (84)		0.20
	No	26 (10.3)	225 (89.7)	1.2	
Used antibiotic within three months	Yes	17 (7.3)	59 (92.7)		0.001*
	No	16 (7.6)	203 (92.4)	12.9	
How often do you wash your hands	Always	10 (6.5)	143 (93.5)		0.01*
	Usually	23 (16.2)	119 (83.8)	6.9	
How often do you use hand rubs	Frequently	9 (7.0)	120 (93.0)		0.001*
	Always	18 (11.8)	134 (88.2)	16.5	
	Rare	6 (42.9)	8 (57.1)		
Smokes cigarette	Yes	1 (10)	9 (90)		0.69
	No	32 (11.2)	253 (88.8)	0.15	
Live with another person who smokes	Yes	19 (95)	1 (5)		0.001*
	No	14 (5)	261 (95)	151.7	
Live with pet animal	Yes	32 (55.2)	26 (44.8)		0.001*
	No	1 (0.4)	236 (99.6)	140.6	
Had Chronic disease	Yes	23 (69.7)	10 (30.3)		0.001*
	No	10 (3.8)	252 (96.2)	123.3	

Note: *Statistical significance.

among others. Equally likely is the proposition that the data reflect an actual increase in the prevalence of MRSA over the years or a transient local outbreak.

Inside the cutting-edge look, the MRSA carriage rate turned particularly high amongst surgical wards (30.6%). This result I compared with the corresponding study in Gaza Strip,[28] Assam[25] and Dessie, Ethiopia.[12] This result is probably explained by frequent contact with patients and increased load in surgical wards.

According to this study, health-care workers who frequently used hand sanitiser and infrequently cleaned their hands had a higher risk of developing MRSA anterior nares colonization than those who did not. They were also statistically more likely to carry MRSA in their noses than those who did. This finding is comparable with the corresponding previous studies in Ethiopia[23] and other parts of the world.[29–31] The temporary hand carriage of bacteria on the hands of HCWs could account for the primary mechanism for the auto-transmission from contaminated hand to nose.

The index study also showed a clear association between the acquisition of MRSA and patients who had taken antibiotics earlier. This was also reported from findings in Nigeria,[32] Tanzania,[6] and Assam.[33] This could be mainly because antibiotic use offers selective stress favouring resistant bacterial strains. Particularly, inappropriate use increases the selection and dissemination of antibiotic-resistant bacteria.

The present study analyzed results to help to know the impact on the prevalence rate of MRSA with the duration of health-care year services which has a significant difference. Similar effects had been pronounced in a study carried out at tertiary and regional hospitals in Dar es Salaam, Tanzania[6] Although, the difference was not statistically significant. Probably due to dealing with patients for a longer period of years may increase the risk of exposure to total colonization. On the other hand, this is contrary to the findings stated from different parts of the world this claim which that higher the prevalence rate of MRSA among the younger and less practised health-care workers could be due to their lack of knowledge about infection control policies and their missing experience in taking care of the patient.[26,34] There could be a variation in the intensity of exposure to MRSA-colonized health-care workers and patients in the two settings, which could account for the observed difference.

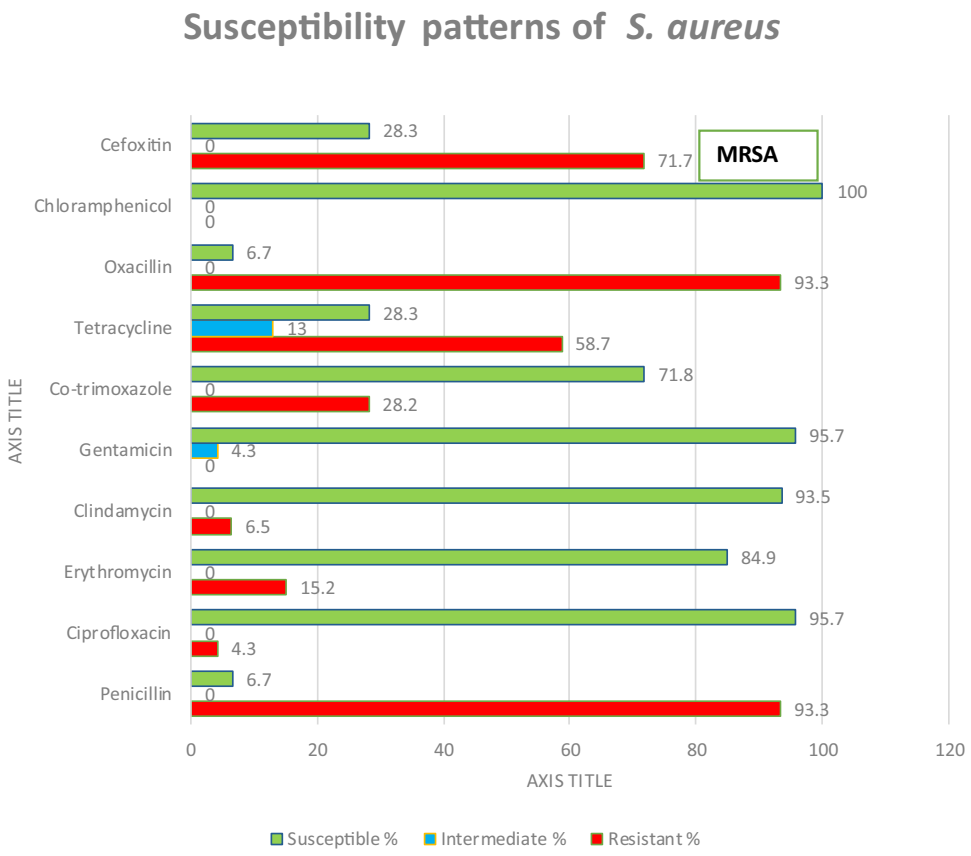

Figure 1 Antimicrobial susceptibility patterns of *S. aureus* among health professionals in HFSUH and Jugol Hospitals, Harar, eastern Ethiopia, 2021.

In this study, older individuals are more likely to be colonized with MRSA. This is in line with several other investigations in which being older is a risk factor for colonization.[35–37] Additionally, the presence of underlying chronic disease was found to be a risk factor for colonization which is in agreement with a study from Osnabruck, Germany,[38] and Dessie, Ethiopia.[12] This may be attributed to the fact that being older and having the underlying disease can lead to a lower immune status which in turn opens the way to be colonized or other reasons which will be studied in future.

Another important factor that was statistically associated with the prevalence of MRSA was having contact with pet or farm animals. Similar findings have been observed in German Rehabilitation Centers and the Netherlands where MRSA carriage in health-care workers in contact with livestock is higher than in other health-care workers, though the difference is not statistically significant.[39,40] The possible explanation may be due to the likelihood of animal-to-human transmission through kissing, licking, bathing, or other coordinated contacts with colonized animals.

Concerning antimicrobial susceptibility patterns of the isolates, increasing resistance was observed in 93.3% showed resistance to both penicillin and oxacillin despite slight differences in the reported figures, the susceptibility patterns of antimicrobial were in line with the study from, India (93%),[41] (97%) seen in Pakistan,[19] (93.1%) in Ethiopia[23] and oxacillin, which is reported (82.5%) in Gaza Strip.[28] The resistance to the above antibiotics could be mainly due to excessive use, misuse, and irrational prescription of these medications, therefore highly available for abuse. Suggesting antibiotic susceptibility tests before treatment is essential in these patients, given the high resistance rates of *S. aureus* to these aforementioned antibiotics, treatment of *S. aureus* infections at our hospitals with these antibiotics may not be effective.

Our findings showed comparatively lower resistance to ciprofloxacin (4.3%) and clindamycin (6.5%) which is near to (3.92%), finding in Gaza Strip[28] and the present study, no resistant isolate is observed for chloramphenicol. The high sensitivity to these antibiotics in this environment is because they are not routinely used due to high cost and limited availability. As a result, the use of these drugs to treat suspected cases of MRSA infections will be appropriate in this

environment. In contrast, a study from Jimma town observed high resistance to chloramphenicol.[42] The reason for this variation could be studied in the future.

Higher susceptibility was also shown in the present study compared to the studies on health-care workers in Ethiopia for gentamycin (37.9%), erythromycin (62.1), clindamycin (17.2%), and ciprofloxacin (37.9%)[23] and gentamycin (60.4%), erythromycin (32.7%), clindamycin (27.5%), and ciprofloxacin (63.7%) in Nepal.[43] This variation might be due to the local infection prevention and control strategies of the hospital settings.

In our finding, lower resistance was reported for tetracycline (57.80%) than a study from India[41] but higher resistance was observed in Gaza Strip[28] and Southern China.[44] This might be due to the variation in the geographical area because most significant bacterial pathogens like MRSA are disseminated from different clones in different regions and policies for antibiotic prescription and the commercial availability of antibiotics without a medical doctor description in our study area.

Conclusion

The prevalence of nasal carriage of *S. aureus* and MRSA among health-care workers in this study was high. Demographic and behavioural conditions like older age, longer working experience, being exposed to the surgical ward, failing to wash hands and using hand rub, land living with or frequent exposure to cigarette smokers and farm or pet animals were significantly associated with nasal carriage of MRSA among health-care workers. In addition, medical factors such as the previous usage of antibiotics, and underlying chronic diseases showed an association with MRSA carriage.

The study emphasizes the need for regular surveillance of hospital staff in the theatre environment to prevent MRSA transmission among health-care personnel, visitors/patient attendants and patients. Strict adherence to infection control practices is essential to limit the spread of MRSA through frequent hand-washing habits before, after and even in between every patient visit or medical procedure.

Data Sharing Statement

The data sets generated during and/or analyzed during the current study are available from the corresponding authors upon reasonable request.

Ethical Approval and Consent

Ethical clearance for the study was obtained from the Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University College of Health and Medical Science. This study is in accordance with the Declaration of Helsinki. Official letters of support were written to public hospitals. An official letter of support was obtained from HFSUH and Jugol Hospitals before data collection. Informed written consent was obtained from each participant after explaining the objectives of the study. Information obtained from study participants was kept confidential. The participants were informed about the positive for MRSA. Moreover, the data collector and participants were protected from COVID-19 exposure at the time of the study by using appropriate infection prevention measures.

Acknowledgments

We are thankful to the division of Medical Microbiology staff for their unreserved support. We gratefully thank Jugol General Hospital and HFSUH administrative and HCWs for their kind cooperation.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This research data collection finance was covered by Haramaya University's postgraduate directorate.

Disclosure

The authors declare no conflicts of interest in this work.

References

1. Sakr A, Brégeon F, Mège J-L, Rolain J-M, Blin O. Staphylococcus aureus nasal colonization: an update on mechanisms, epidemiology, risk factors, and subsequent infections. *Front Microbiol*. 2018;9:2419.
2. Treesirichod A, Hantagool S, Prommalikit O. Nasal carriage and antimicrobial susceptibility of Staphylococcus aureus among medical students at the HRH princess Maha Chakri sirindhorn medical center, Thailand: an across-sectionally. *J Infect Public Health*. 2013;6(3):196–201. doi:10.1016/j.jiph.2012.12.004
3. Naicker PR, Karayem K, Hoek KG, Harvey J, Wasserman E. Biofilm formation in invasive Staphylococcus aureus isolates is associated with the clonal lineage. *Microb Pathog*. 2016;90:41–49. doi:10.1016/j.micpath.2015.10.023
4. Bassetti M, Del Puente F, Magnasco L, Giacobbe DR. Innovative therapies for acute bacterial skin and skin-structure infections (ABSSSI) caused by methicillin-resistant Staphylococcus aureus: advances in Phase I and II trials. *Expert Opin Investig Drugs*. 2020;2020;1–12.
5. Thembo N, Masifa G, Kamugisha G, et al. Methicillin Resistant Staphylococcus aureus nasal carriage and associated factors in a rural tertiary hospital in Eastern Uganda: a prospective cross-sectional study; 2020.
6. Moyo SJ, Nkinda L, Majigo M, et al. Nasal carriage of methicillin-resistant Staphylococcus aureus among health care workers in tertiary and regional Hospitals in Dar es Salam, Tanzania. *Int J Microbiol*. 2018;2018:1.
7. Kong Y, Ye J, Zhou W, et al. Prevalence of methicillin-resistant Staphylococcus aureus colonisation among healthcare workers at a tertiary care hospital in southeastern China. *J Glob Antimicrob Resist*. 2018;15:256–261. doi:10.1016/j.jgar.2018.08.013
8. Khatri S, Pant ND, Bhandari R, et al. NasThe nasalrriage rate of methicillin-resistant staphylococcus aureus among health care workers at a tertiary care hospital in Kathmandu, Nepal. *J Nepal Health Res Counc*. 2017;15(1):26–30.
9. Ohagim IP, Nyong EE, Moses AE. Methicillin-resistant Staphylococcus aureus nasal carriage among surgical patients, patient relatives and healthcare workers in a teaching hospital in Uyo, South Nigeria. *J Adv Microbiol*. 2018;2018:1–11.
10. Sobhy N, Aly F, El Kader OA, Ghazal A, ElBaradei A. Community-acquired methicillin-resistant Staphylococcus aureus from skin and soft tissue infections (in a sample of Egyptian population): analysis of mec gene and staphylococcal cassette chromosome. *Braz J Infect Dis*. 2012;16(5):426–431.
11. Vandepitte J, Verhaegen J, Engbaek K, et al. *Basic Laboratory Procedures in Clinical Bacteriology*. World Health Organization; 2003.
12. Shibabaw A, Abebe T, Mihret A. Nasal carriage rate of methicillin-resistant Staphylococcus aureus among Dessie referral hospital health care workers; Dessie, Northeast Ethiopia. *Antimicrob Resist Infect Control*. 2013;2(1):25. doi:10.1186/2047-2994-2-25
13. Cheesbrough M. *District Laboratory Practice in Tropical Countries, Part 2*. Cambridge University press; 2005.
14. Kirby B. Kirby-Bauer disk diffusion susceptibility test protocol. *Am Soc Microbiol*. 2009;66:208.
15. CLSI. *Performance Standards for Antimicrobial Susceptibility Testing*. 30th ed. Wayne, PA: Clinical and Laboratory Standards Institute M100; 2020.
16. Immergluck LC, Satola SW, Jain S, et al. Methicillin-resistant Staphylococcus aureus colonization among pediatric healthcare workers from different outpatient settings. *Am J Infect Control*. 2013;41(9):841–843. doi:10.1016/j.ajic.2012.11.014
17. De Boeck H, Vandendriessche S, Hallin M, et al. Staphylococcus aureus nasal carriage among healthcare workers in Kisangani, the Democratic Republic of the Congo. *Eur J Clin Microbiol Infect Dis*. 2015;34(8):1567–1572.
18. Khanal R, Sah P, Lamichhane P, Lamsal A, Upadhaya S, Pahwa VK. Nasal carriage of methicillin-resistant staphylococcus aureus among health care workers at a tertiary care hospital in Western Nepal. *Antimicrob Resist Infect Control*. 2015;4(1):1–5.
19. Rashid Z, Farzana K, Sattar A, Murtaza G. Prevalence of nasal Staphylococcus aureus and methicillin-resistant Staphylococcus aureus in hospital personnel and associated risk factors. *Acta Pol Pharm*. 2012;69(5):985–991.
20. Kakhandki LS, Peerapur BV. Study of nasal carriage of MRSA among the clinical staff and health care workers of a teaching hospital of Karnataka, India. *Al Ameen J Med Sci*. 2012;5(4):367–370.
21. Al-Abdli NE, Baiu SH. Nasal carriage of Staphylococcus aureus in health care workers in Benghazi hospitals. *Am J Microbiol Res*. 2014;2(4):110–112. doi:10.12691/ajmr-2-4-1
22. Kodiya M, Ngamdu YB, Baba AS, et al. Nasal carriage of Methicillin-Resistant Staphylococcus aureus among healthcare workers in University of Maiduguri teaching hospital.
23. Legese H, Kahsay AG, Kahsay A, et al. Nasal carriage, risk factors and antimicrobial susceptibility pattern of methicillin-resistant Staphylococcus aureus among healthcare workers in Adigrat and Wukro hospitals, Tigray, Northern Ethiopia. *BMC Res Notes*. 2018;11(1):250.
24. Singh N, Mohanty S, Panda SS, Sahoo S, Pattnaik D, Jena J. Methicillin-resistant Staphylococcus aureus (MRSA) carriage among health care workers in a tertiary care hospital in Bhubaneswar. *Int J Community Med Public Health*. 2018;5(8):3276. doi:10.18203/2394-6040.ijcmph20182970
25. Gogoi M, Khan AR, Sharma A, Mohan DG. Nasal and hand carriage of methicillin-resistant Staphylococcus aureus among health care workers of a tertiary care hospital in North-East India. *IOSR J Dent Med Sci*. 2017;16:36–41.
26. Al-Humaidan OS, El-Kersh TA, Al-Akeel RA. Risk factors of nasal carriage of Staphylococcus aureus and methicillin-resistant Staphylococcus aureus among health care staff in a teaching hospital in central Saudi Arabia. *Saudi Med J*. 2015;36(9):1084. doi:10.15537/smj.2015.9.12460
27. Abimana JB, Kato CD, Bazira J. Methicillin-resistant Staphylococcus aureus nasal colonization among healthcare workers at Kampala International University teaching hospital, Southwestern Uganda. *Can J Infect Dis MedMicrobiol*. 2019;2019:1–7. doi:10.1155/2019/4157869
28. El Aila NA, Al Laham NA, Ayesh BM. Nasal carriage of methicillin-resistant Staphylococcus aureus among health care workers at Al Shifa hospital in Gaza Strip. *BMC Infect Dis*. 2017;17(1):1–7. doi:10.1186/s12879-016-2139-1
29. Chamchod F, Ruan S, Roberts MG. Modeling the spread of methicillin-resistant Staphylococcus aureus in nursing homes for elderly. *PLoS One*. 2012;7(1):e29757. doi:10.1371/journal.pone.0029757
30. Saadatian-Elahi M, Tristan A, Laurent F, et al. Basic rules of hygiene protect health care and lab workers from nasal colonization by Staphylococcus aureus: an international cross-sectional study. *PLoS One*. 2013;8(12):e82851. doi:10.1371/journal.pone.0082851
31. Pan S-C, Tien K-L, Hung IC, et al. Compliance of health care workers with hand hygiene practices: independent advantages of overt and covert observers. *PLoS One*. 2013;8(1). doi:10.1371/journal.pone.0053746

32. Wichendu PN, Wariso KT, Igunma AJ, et al. Nasal Carriage Rate of Methicillin Resistant Staphylococcus Aureus Among Theatre. Staff of Upth. Rivers State, Nigeria.
33. Rongpharpi SR, Hazarika NK, Kalita H. The prevalence of nasal carriage of Staphylococcus aureus among healthcare workers at a tertiary care hospital in Assam with special reference to MRSA. *J Clin Diagn Res*. 2013;7(2):257.
34. Abdulaziz MM. Nasal carriage of methicillin-resistant staphylococcus aureus among healthcare workers high-risk units of Ahmadu Bello University teaching hospital, Zaria. *Fac Pathol*. 2015. doi:10.1016/j.ijid.2016.02.220
35. Gomes IM, Marlow MA, Pinheiro MG, et al. Risk factors for Staphylococcus aureus and methicillin-resistant S aureus colonization among health care workers in paediatrics departments. *Am J Infect Control*. 2014;42(8):918–920. doi:10.1016/j.ajic.2014.05.009
36. Baroja I, Guerra S, Coral-Almeida M, et al. Methicillin-resistant Staphylococcus aureus nasal colonization among health care workers of a tertiary hospital in Ecuador and associated risk factors. *Infect Drug Resist*. 2021;14:3433. doi:10.2147/IDR.S326148
37. Thomas S, Karas JA, Emery M, Clark G. Meticillin-resistant Staphylococcus aureus carriage among district nurse patients and medical admissions in a UK district. *J Hosp Infect*. 2007;66(4):369–373. doi:10.1016/j.jhin.2007.05.004
38. Brans R, Kaup O, Schürer NY. Occupational MRSA infection: risk factor, disposition, prevention, and therapy. In: *Kanerva's Occupational Dermatology*. Springer; 2020:1493–1504.
39. Schubert M, Kämpf D, Wahl M, et al. MRSA point prevalence among health care workers in German rehabilitation centers: a multi-center, cross-sectional study in a non-outbreak setting. *Int J Environ Res Public Health*. 2019;16(9):1660. doi:10.3390/ijerph16091660
40. Wulf MWH, Tiemersma E, Kluytmans J, et al. MRSA carriage in healthcare personnel in contact with farm animals. *J Hosp Infect*. 2008;70 (2):186–190. doi:10.1016/j.jhin.2008.06.006
41. Malini J, Harle SA, Padmavathy M, et al. Methicillin-resistant Staphylococcus aureus carriage among the health care workers in a tertiary care hospital. *J Clin Diagnostic Res*. 2012;6(5):791–793.
42. Kejela T, Bacha K. Prevalence and antibiotic susceptibility pattern of methicillin-resistant Staphylococcus aureus (MRSA) among primary school children and prisoners in Jimma Town, Southwest Ethiopia. *Ann Clin Microbiol Antimicrob*. 2013;12(1):1–11. doi:10.1186/1476-0711-12-11
43. Ansari S, Nepal HP, Gautam R, Rayamajhi N, Shrestha S. The threat of drug-resistant staphylococcus aureus to health in Nepal. *BMC Infect Dis*. 2014;14(1):1–5.
44. Chen B, Dai X, He B, et al. Differences in Staphylococcus aureus nasal carriage and molecular characteristics among community residents and healthcare workers at Sun Yat-Sen University, Guangzhou, Southern China. *BMC Infect Dis*. 2015;15(1):1–12.