ISSN: 2643-4008

Nour and Hashi. Int Arch Med Microbiol 2023, 5:020
DOI: 10.23937/2643-4008/1710020
Volume 5 | Issue 1
Open Access

International Archives of
Medical Microbiology

RESEARCH ARTICLE

Carriage Rate and Antimicrobial Resistance Profile of Staphylococcus aureus among Healthcare Workers at Edna Adan University Hospital

Hussein Mohamoud Nour, MSc[1*] and Khadar Mohamed Hashi[2]

[1]*Edna Adan University, Hargeisa, Somaliland*

[2]*Edna Adan Hospital, Hargeisa, Somaliland*

***Corresponding author:** *Hussein Mohamoud Nour, MSc, Edna Adan University, Hargeisa, Somaliland, Tel: +252634425168*

Abstract

Background: *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]. 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.

Ranking as the second most common cause of hospital acquired (nosocomial) bloodstream infections [2]. About 20% of patients undergoing surgery acquire at least one nosocomial *S. aureus* infection, leading to increased morbidity, mortality, hospital stay, and costs [2]. However, there is no any previous study conducted regarding this topic in Hargeisa, Somaliland.

Objectives: The main objective of this study was to determine the Carriage rate and Antimicrobial resistance Profile of *Staphylococcus aureus* Among Healthcare Workers at Edna Adan University Hospital.

Methods: Hospital-based cross-sectional was conducted on a total of 80 healthcare workers from **July** to **August** 2023 at EAUH. A simple random sampling technique was used and Samples were collected from HCWs at EAUH from July to August 2023. By using pre-moistened sterile cotton swabs and specimens were collected from the anterior nares and palms of the HCWs. The samples were collected by rotating the swabs gently two to three times on both nares of the study participants. Similarly, a second swab was used to collect specimen from both palms of the health care workers. Both swabs were cultured on blood agar and subculture onto Manitol Salt agar and incubated at 37 °C for 24 hrs.

Results: The overall prevalence of *Staphylococcus aureus* in this study was 20% (16/80) and methicillin-resistant *Staphylococcus aureus* was 7.5% (6/80). Carriage rate was highest among midwifes 7(29.2%) followed by nurses 5(26.3%) and doctors (3(17.6%) respectively. Similarly highest colonization rate of MRSA 3(60%) were observed among nurses and doctors 1(50%) followed by midwifes 2(28.6%). Length of healthcare service was significantly associated with MRSA colonization. Highest rate of resistance (100%) was found against Ampicillin, Cefoxitin (93.7%) Erythromycin (87.5%) and Gentamycin (68.75%) respectively. *S. aureus* was found to be highly sensitive to Doxycycline (100%) Ciprofloxacin (100%) and Clindamycin (87.5%). Similarly, MRSA was completely showed (100%) resistance against Cefoxitin and ampicillin.

Conclusion: The prevalence of *Staphylococcus aureus* and Methicillin-resistant *Staphylococcus aureus* are high in this study. The present study encourages the need for regular screening and surveillance among hospital staff and the environment to prevent MRSA transmission among health-care personnel and Molecular detection of highly resistant strains of MRSA are suggested.

Keywords

S. aureus carriage, Healthcare workers, Hargeisa, Somaliland

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].

Citation: Nour HM, Hashi KM (2023) Carriage Rate and Antimicrobial Resistance Profile of *Staphylococcus aureus* among Healthcare Workers at Edna Adan University Hospital. Int Arch Med Microbiol 5:020. doi.org/10.23937/2643-4008/1710020

Accepted: December 04, 2023: **Published:** December 06, 2023

Ranking as the second most common cause of hospital acquired (nosocomial) bloodstream infections [2]. About 20% of patients undergoing surgery acquire at least one nosocomial *S. aureus* infection, leading to increased morbidity, mortality, hospital stay, and costs. Infections due to *S. aureus* strains could be caused by strains circulating in the community or present in hospital environments [3]. However *S. aureus* has also been known to colonize several sites of the human body in normal healthy people with the primary ecological niche being the anterior parts of the nares. From the anterior nares, *S. aureus* can be seeded in other extra-nasal sites which may include hands, pharynx, vagina, axillae, and skin that is either intact or inflamed. These sites may also be colonized without involvement of the anterior nares [4].

Carriage of *S. aureus* among healthcare workers (HCWs) has been documented to be a risk factor for transmission of the bacteria and the subsequent development of staphylococcal infections among patients in hospital settings and other health facilities [5]. Auto-infections among carriers also occur frequently [6]. The transmission of the bacteria from colonized or infected health care workers always occurs by direct contact or through fomites such as contaminated equipment or environment [7]. Increased Carriage of the bacteria on hands indicates poor hygiene practices among health care workers [8]. In addition, colonized HCWs provide a link through which cross transmission between community-acquired and hospital-acquired *S. aureus* occurs [9].

The emergence of virulent and multidrug-resistant strains has increased the morbidity rates and impeded effective treatment of *S. aureus* infections. Notably among these resistance mechanisms is methicillin resistance (MRSA), which is due to acquisition of a mecA gene by *S. aureus* strains. This gene encodes for an alteration in the penicillin-binding proteins (PBP) leading to their decreased affinity for β-lactam antibiotics [10]. MRSA is usually spread by direct contact with an infected wound or from contaminated hands, usually those of healthcare providers [11]. The increasing prevalence of *S. aureus*, especially MRSA strains among HCWs worldwide is a growing public health concern. However, there is a limited information regarding the prevalence, risk factors and antimicrobial susceptibility patterns of *S. aureus* among HCWs in sub-Saharan African countries, including Somaliland. Therefore the knowledge on carriage rate among HCWs of *S. aureus* isolates and their antimicrobial resistance pattern provide the baseline data for infection control measures. The aim of this study was to assess the carriage rate and the antimicrobial susceptibility profile of *S. aureus* from the health care workers Edna Adan University Hospital in Somaliland.

Materials and Methods

Study site and design

The Edna Adan hospital was founded by Edna Adan Ismail, a famous lady in the context of Somalia and the world as well. The hospital located in Maroodi Jeex region, the capital city of Somaliland known as Hargeisa. EAUH is found in southern of Hargeisa. Based on census conducted in 2012, Hargeisa has a total population of 1.6 million (Central Statistics Department of Somaliland) The city has one referral Hospital, two general Hospitals, seven health care centers and five private Hospitals and other several private clinics.

The EAUH is one of the largest private hospitals in the city, which provides health services for the community especially, maternal and child health services, for patients from all parts of Somaliland and other neighborhood regions such as puntland, and southern Somalia.

A facility-based cross-sectional study was conducted from July to August 2023 in Edna Adan Hospital. Hargeisa, Somaliland. Health care workers at Edna Adan University Hospital that come in direct contact with patients were included in the study. Staffs not involved in the provision of direct healthcare services such as office workers and those have current disease compatible with *S. aureus* were excluded from the study.

Sample size determination and sampling technique

All the HCWs working all the hospital departments were included in the study. Participants were recruited on a voluntary basis during their regular activities. An informed consent form was made available to each participant who also completed a question naira's regarding demographic data. Such as sex, age, history of chronic diseases, recent use of antibiotics, level of education, profession and length of healthcare services.

Specimen collection and bacterial culture

Samples were collected from HCWs at EAUH from June to July 2023. By using pre-moistened sterile cotton swabs and specimens were collected from the anterior nares and palms of the HCWs. The samples were collected by rotating the swabs gently two to three times on both nares of the study participants. Similarly, a second swab was used to collect specimen from both palms of the health care workers. The samples were immediately processed within two hours and inoculated into blood agar and incubated at 37 °C for 48 hr. Colonies that were brown or white, beta-haemolytic and round, characteristic of *S. aureus*, were sub-cultured onto mannitol salt agar and incubated at 37 °C for 24 h. Again, Colonies that were golden yellowish in appearance on MSA were identified as *S. aureus*. Further identifications were done by gram stain and other biochemical tests such as Catalase and coagulase. Isolates that were Gram-positive, cocci-shaped, arranged in pairs and clusters,

positive for catalase and coagulase were identified as *S. aureus*.

Antimicrobial susceptibility testing

The bacteria was tested against different antimicrobial drugs using the Kirby-Bauer disc diffusion method [12]. The bacterial inoculum was prepared by making a saline suspension of isolated colonies from 24 h Mannitol salt agar plate and the suspension was adjusted with 0.5 McFarland turbidity standards by using sterile saline. A sterile cotton swab was dipped into the adjusted suspension and streaked on a Mueller-Hinton agar plate. Commercially available discs of 30 µg vancomycin, 5 µg ciprofloxacin, 10 µg gentamicin, 15 µg erythromycin, 30 µg amikacin, 10 µg Ampicillin, 30 µg Doxycycline and 2 µg clindamycin were used. The antimicrobial discs were placed firmly on the surface of the inoculated Mueller-Hinton agar plate by using sterile forceps and the plates were then incubated 37 °C. After 18h-24h of incubation, the plates were examined and the diameters of the zones of inhibition were measured. The Results were determined as susceptible, intermediate, and resistant according to the guidelines of the Clinical and Laboratory Standards Institute [13]. Identification of MRSA isolates was done using 30 µg cefoxitin antibiotic discs on Mueller-Hinton agar plate according to standard guidelines [13].

Statistical analysis

The analysis of categorical data was done using SPSS version 23 software. *S. aureus* carriage was the dependent variable. Factors that could predispose to carriage of *S. aureus* among the health care workers such age, length of healthcare service, profession, presence of chronic debilitating conditions, history of antibiotic use and gender were the independent variables. Chi-square was used to analyze all the variables for significance and statistical significance was identified as $p < 0.05$.

Ethical considerations

The present study was approved by (office of postgraduate) Edna Adan University, and all experiments were performed in accordance with relevant guidelines and regulations. Participants' information were anonymized prior to analysis and the confidentiality was assured by the researchers.

Result

A total of 80 healthcare workers were recruited in the study and were screened for *S. aureus* carriage with a response rate of (100%). Among 80 healthcare workers, 16(20%) were positive for *S. aureus*. The age ranged between 20 and > 40 years (Mean age = 32.2 ± 8.22). 44(55%) were females and 36(45%) were males. The majority 24 (30%) of the health care workers were midwifes followed by 20(25%) were nurses. Regarding the length of the health care service of the participants, majority 38 (47%) had been working 1-5 years in the hospital (Table 1).

Table 1: Sociodemographic characteristics.

Variables	Categories	Frequency	Percentage
Sex	Male	36	45%
	Female	44	55%
	Total	80	100%
Age	20-29	42	52.5%
	30-39	35	43.8%
	> 40	3	3.8%
	Total	80	100%
History of hypertension	Yes	5	6.3%
	No	75	93.8%
	Total	80	100%
History of diabetics	Yes	4	5.0%
	No	76	95.0%
	Total	80	100%
Recent use of antibiotics	Yes	17	21.3%
	No	63	78.8%
	Total	80	100%
Profession/Occupation	Nurse	20	25%
	Midwife	24	30%
	Doctor	16	20%
	Lab tech	8	10%
	Anesthesiologists	12	15.0%
	Total	80	100%

Length of healthcare Service	1-5 years	38	47.5%
	6-10 years	21	26.3%
	> 10 years	21	26.3%
	Total	80	100%
Status of *S. aureus* of healthcare workers	*S. aureus* Carriers	16	20%
	S. aureus non-carriers	64	80%
	Total	80	100%

Table 2: Distribution of *S. aureus* carriage by Age, Sex and profession.

	***S. aureus* Carriers n (%)**	***S. aureus* non-carriers n (%)**
By Age		
20-29	6(14.6%)	35(85.4)
30-39	8(22.2%)	28(77.7)
> 40	2(66.6%)	1(33.3)
	16	64
By Sex		
Male	6(16.6%)	30(83.3)
Female	10(22.7%)	34(77.27)
	16	64
By profession		
Nurses	5(26.3%)	14(73.7%)
Midwifes	7(29.2%)	17(70.83%)
Doctors	3(17.6%)	14(82.4%)
Laboratories	0(0.00%)	8(100%)
Anesthesiologists	1(8.3%)	11(91.6%)
	16	64

Table 3: Distribution of *S. aureus* and MRSA carriage among the health professions.

Profession	***S. aureus* (n = 16)**	**MRSA (n = 6)**
Nurses	5(26.3)	3(60%)
Midwifes	7(29.2)	2(28.6%)
Doctors	2(11.7)	1(50%)
Laboratories	1(12.5)	0(0.0%)
Anesthesiologists	1(8.3)	0(0.0%)
	16	6

Distribution of *S. aureus* Carriage by age, sex and profession

As Table 2 depicted, the highest *S. aureus* carriers 2(66.6%) were observed among healthcare > 40-years-old followed by who were 30-39 years 8(22.2%), those who were females 10(22.7%) and those who were midwifes 7(29.2) followed by 5(26.3%) nurses.

Distribution of *S. aureus* and MRSA carriage among the health professions

A total of 6 MRSA were isolated from 80 participants giving an overall colonization rate of (7.5%). Among the 36 males screened 6(16.6%) and 4(11.1%) were positive for *S. aureus* and MRSA respectively, when compared to 10(22.7%) 2(4.5%) of the 44 females screened. Similarly highest colonization rate of MRSA 3(60%) were observed among nurses and doctors 1(50%) followed by midwifes 2(28.6%). Conversely, No MRSA carriage was detected among the anesthesiologists and laboratory technicians (Table 3, Table 4 and Table 5).

The antimicrobial susceptibility patterns were performed for the *S. aureus* isolates against antimicrobials using conventional dis diffusion. All *S. aureus* isolates were completely sensitive to Ciprofloxacin (100%), Doxycycline (100%) and (87.5%) sensitive to Clindamycin. Hence these drugs were found to be the most effective drugs against *S. aureus* in the study area. However, highest resistant was detected to Ampicillin (100%) followed by Erythromycin (87.5%), Gentamycin (68.75%) and Amikacin (56.25%) respectively (Table 6).

Discussion

This study reports the carriage rate for *S. aureus* among HCWs at the Edna Adan University Hospital. Edna Adan Hospital is one of the largest Maternity hospital in Somaliland. The overall carriage rate of *S. aureus* among health care workers was found to be 20%.

The findings of this study is comparable similar study done in India where the carriage rate of *S. aureus* was (20.7%) [14]. And Oman (20.5% [15]. However, similar

Table 4: Potential factors associated with MRSA Colonization among the HCW at EAUH.

Associated factor	MRSA Colonization	P-value
Age		0.503
20-29	2(4.8%)	
30-39	4(11.4%)	
> 40	0(0.0%)	
Sex		0.085
Male	4(11.1%)	
Female	2(4.5%)	
History of hypertension		0.241
Yes	1(20.0%)	
No	5(6.7%)	
History of diabetics		0.124
Yes	0(0.0%)	
No	6(6.7%)	
Recent use of antibiotics		0.682
Yes	1(5.9%)	
No	5(7.9%)	
Profession		0.440
Nurses	3(15%)	
Midwifes	2(8.3%)	
Doctors	1(8.3%)	
Lab tech	0(0.0%)	
Anesthesiologists	0(0.0%)	
Length of healthcare service		**0.033***
1-5 years	1(2.6%)	
6-10 years	4(19.05%)	
> 10 years	1(4.8%)	

*Statistical analysis was performed by Chi square ($p < 0.05$) and only length of healthcare service was significant associated with the colonization of MRSA among HCW at EAUH.

studies have reported higher carriage rate of *S. aureus* in other developing countries than we have reported in this study. Such as Gabon (29%) [16], Ethiopia (28.8) [17], Principe (23.7%) [18] and Egypt (29.%) [19]. conversely, lower findings of *S. aureus* colonization rate have been reported from Madagascar (11%) [20], Yekatit 12 hospital, Ethiopia (14.3%) [21] and Nigeria (17.3%) [22]. The difference of carriage rate of *S. aureus* among HCW might due to variations of microbiological procedures, sampling techniques, study populations, infection control and preventive measures and rationale antibiotic usage which varies from hospital to hospital.

Regarding the colonization rate of MRSA among the healthcare workers in the current study, we found that the MRSA colonization rate was 7.5%. Higher burden of MRSA colonization rate was found among the females (22.7%) which is comparable with similar study conducted in Dar Al salam Hospital, Tanzania where the carriage rate among female HCW was 45.5% [23]. It is However. Contradicts from similar study conducted in

Table 5: Antimicrobial susceptibility profile of the isolated *S. aureus*.

Antibiotics	Sensitive n (%)	Resistant n (%)
Ampicillin	0(0.0%)	16(100%)
Doxycycline	16(100%)	0(0.00%)
Clindamycin	14(87.5%)	2(12.5%)
Cefoxitin	1(6.3%)	15(93.7%)
Amikacin	7(43.75%)	9(56.25%)
Gentamycin	5(31.25%)	11(68.75%)
Ciprofloxacin	16(100%)	0(0.00%)
Erythromycin	2(12.5%)	14(87.5%)

Table 6: Antimicrobial susceptibility pattern of MRSA (n = 6).

Antibiotics	Sensitive n (%)	Resistant n (%)
Ampicillin	(0.0%)	6(100%)
Doxycycline	3(50%)	3(50%)
Clindamycin	4(66.7%)	2(33.3%)
Cefoxitin	0(6.3%)	6(100%)
Amikacin	2(33.3%)	4(66.7%)
Gentamycin	1(16.7%)	5(83.3%)
Ciprofloxacin	5(83.3%)	1(16.7%)
Erythromycin	2(33.3%)	4(66.7%)

Tikur Anbessa Hospital, Ethiopia (39.3%) [24] In which high carriage rate of MRSA was observed among males. However, the carriage rate of MRSA among HCW in the current study was higher than studies conducted in India (2.5%) [25] Ethiopia (5.8%) [26] and Kenya where no MRSA carriage was found among the healthcare workers [27]. But lower than similar studies done in elsewhere like Egypt (13.5%) [28], Ethiopia (12.7%) [26], Libya (19%) [29] and Tanzania (15.6%) [30]. The variations could be therefore, as a result of difference in microbiological procedures such as incubation period of the culture during antimicrobial sensitivity testing and local adherence of antibiotics usages among the healthcare workers.

In addition, highest colonization rate of MRSA 3(60%) were observed among nurses and doctors 1(50%) followed by midwifes 2(28.6%). Which is coincides with similar study conducted in Harar, Eastern Ethiopia where nursing and doctors carriage of MRSA were reported 15.3%, 11.1% respectively [31]. GAZA strip, where nursing and doctors carriage of MRSA were also observed (30.4%) and (16%) respectively [32].

These findings could be attributed by the increased physical contact of nurses and doctors with patients in the study area.

The present study assessed results to help to know the impact on the carriage rate of MRSA with the duration of length of healthcare services which has a significant difference. Similar effects had been made in a study carried out at tertiary and regional hospitals in

Dar Salaam, Tanzania [30] although, the difference was not statistically significant. In fact due to dealing with patients for a longer period of years may increase the risk of exposure to total colonization.

The present study showed that there was no significant association between carriage of MRSA with sex (p = 0.085), Age (p = 0.503), history of hypertension (p = 0.241), history of diabetics (p = 0.124), recent use of antibiotics (p = 0.682), profession (p = 0.440). But it is, however length of healthcare services (p = **0.033**) was highly significant associated with colonization rate of MRSA which is comparable with similar study done in Ethiopia [31]. Furthermore, relatively high carriage rate of MRSA colonization were observed among the males than females in the current study which is in agreement with those reported in Saudi Arabia [33]. But incomparable with similar study conducted in Ethiopia where females were more colonized by MRSA than males [34].

Understanding of antimicrobial resistance profile of the isolates is an important tool in the successful treatment of infections caused by *S. aureus* and prevention of outbreaks caused by MRSA in hospital settings. In this study high proportions (100%), (87.5%), (68.75%) and (56.25%) of *S. aureus* were resistant to Ampicillin, Erythromycin, Gentamycin and Amikacin respectively. The greater resistance offered by *S. aureus* against commonly used antibiotics could be attributed to many such as misuse and overuse of antibiotics.

In the present study, All *S. aureus* isolates were completely sensitive to Ciprofloxacin (100%), Doxycycline (100%) and (87.5%) sensitive to Clindamycin. Therefore, lower susceptibility of these drugs were reported from studies on healthcare workers in Ethiopia [26]. Resistance rates among MRSA isolates towards Gentamycin, Amikacin, Erythromycin and Doxycycline were significantly higher compared to those observed in *S. aureus*. These findings are similar to that reported in previous study conducted in the same settings [23].

Conclusion

The carriage rate of *S. aureus* and colonization of MRSA among the healthcare workers in Edna Adan University Hospital was relatively high, particularly among midwifes, nurses and doctors. The length of healthcare services was found to be significantly associated with colonization of MRSA. The study emphasizes the need for regular surveillance of hospital staff in the hospital environment to prevent *S. aureus* and MRSA transmission among health-care personnel, visitors, 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 procedures.

Author Contributions

HM was involved in the conception, design, report writing analysis and the interpretation, KH involved specimen collection and manuscript writing. All authors read and approved the final manuscript.

Competing Interest

Authors declare that they have no competing interest.

Funding

The author(s) received no financial support for the research.

Availability of Data and Materials

Not applicable.

Declarations

Ethical approval and consent participate

The present study was approved by (office of postgraduate) Edna Adan University, and all experiments were performed in accordance with relevant guidelines and regulations. Participants' information were anonymized prior to analysis and the confidentiality was assured by the researchers.

Consent for publication

Not applicable.

Acknowledgments

We are thankful to Edna Adan University Hospital and the healthcare workers for their kind support and cooperation during the study period.

References

1. Sakr A, Brégeon F, Mège J-L, Rolain J-M, Blin O (2018) Staphylococcus aureus nasal colonization: An update on mechanisms, epidemiology, risk factors, and subsequent infections. Front Microbiol 9: 2419.
2. Wisplinghoff H, Bischoff T, Tallent SM, Seifert H, Wenzel RP, et al. (2004) Nosocomial bloodstream infections in US hospitals: Analysis of 24,179 cases from a prospective nationwide surveillance study. Clin Infect Dis 39: 309-317.
3. Deurenberg RH, Stobberingh EE (2008) The evolution of Staphylococcus aureus. Infect Genet Evol 8: 747-763.
4. Hamdan-Partida H, Sainz-Espunes T, Bustos-Martinez J (2010) Characterization and persistence of Staphylococcus aureus strains isolated from the anterior nares and throats of healthy carriers in a Mexican community. J Clin Microbiol 48: 1701-1705.
5. Albrich WC, Harbarth S (2008) Health-care workers: Source, vector, or victim of MRSA? Lancet Infect Dis 8: 289-301.
6. Diekema DJ, Pfaller MA, Schmitz FJ, Smayevsky J, Bell J, et al. (2001) Survey of infections due to Staphylococcus species: Frequency of occurrence and antimicrobial susceptibility of isolates collected in the United States, Canada, Latin America, Europe, and the Western Pacific region for the SENTRY Antimicrobial Surveillance Program, 1997-1999. Clin Infect Dis 32: S114-S132.

7. Stevens AM, Hennessy T, Baggett HC, Bruden D, Parks D, et al. (2010) Methicillin-resistant Staphylococcus aureus carriage and risk factors for skin infections, Southwestern Alaska, USA. Emerg Infect Dis 16: 797-803.
8. Lin YC, Lauderdale TL, Lin HM, Chen PC, Cheng MF, et al. (2007) An outbreak of methicillin-resistant Staphylococcus aureus infection in patients of a pediatric intensive care unit and high carriage rate among health care workers. J Microbiol Immunol Infect 40: 325-334.
9. Conceicao T, Coelho C, Santos-Silva I, de Lencastre H, Aires-de-Sousa M (2014) Epidemiology of methicillin-resistant and -susceptible Staphylococcus aureus in Luanda, Angola: First description of the spread of the MRSA ST5-IVa clone in the African continent. Microb Drug Resist 20: 441-449.
10. Harkins CP, Pichon B, Doumith M, Parkhill J, Westh H, et al. (2017) Methicillin-resistant Staphylococcus aureus emerged long before the introduction of methicillin into clinical practice. Genom Biol 18: 130.
11. CDC. MRSA fact sheet. Centers for Disease Control and Prevention.
12. Hudzicki J (2009) Kirby-Bauer disk diffusion susceptibility test protocol. Am Soci Microbiol 2009: 1-23.
13. CLSI (2020) Performance standards for antimicrobial susceptibility testing; Twenty-fifth informational supplement, clinical and laboratory standards institute, Wayne, PA, M100-S25.
14. Ishore K, Prabir G, Mukherjee A, Hazra S (2022) Prevalence of staphylococcal nasal carriage among health care worker working in intensive and critical care units of a tertiary care hospital. J Med Sci Health 8: 1-7.
15. Al Wahaibi L, Al Sudairi R, Balkhair A, Al-Awaisi H, Mabruk M, et al. (2021) S. aureus, MRSA, healthcare-workers, Oman. J Infect Develop Count 15: 1426-1435.
16. Ateba Ngoa U, Schaumburg F, Adegnika AA, Kosters K, Moller T, et al. (2012) Epidemiology and population structure of Staphylococcus aureus in various population groups from a rural and semi urban area in Gabon, Central Africa. Acta Trop 124: 42-47.
17. Shibabaw A, Abebe T, Mihret A (2013) Nasal carriage rate of methicillin resistant staphylococcus aureus among dessie referral hospital health care workers; Dessie, Northeast Ethiopia. Antimicrob Resist Infect Control 2: 25.
18. Conceicao T, Santos Silva I, de Lencastre H, Aires-de-Sousa M (2014) Staphylococcus aureus nasal carriage among patients and health care workers in Sao Tome and Principe, Microb Drug Resist 20: 57-66.
19. Allam AA, Fakhr AE, Mahmoud ME, El-Korashi LA (2021) Staphylococcus aureus nasal colonization among health care workers at an Egyptian tertiary care hospital. Microbes Infect Dis 2: 108-118.
20. Hogan B, Rakotozandrindrainy R, Al-Emran H, Dekker D, Hahn A, et al. (2016) Prevalence of nasal colonisation by methicillin-sensitive and methicillin-resistant Staphylococcus aureus among healthcare workers and students in Madagascar. BMC Infect Dis 16: 420.
21. Dilnessa T, Bitew A (2016) Prevalence and antimicrobial susceptibility pattern of methicillin resistant Staphylococcus aureus isolated from clinical samples at Yekatit 12 hospital medical college, Addis Ababa, Ethiopia. BMC Infect Dis 16: 398.
22. Adeiza SS, Onaolapo JA, Olayinka BO (2020) Prevalence, risk-factors, and antimicrobial susceptibility profile of methicillin-resistant Staphylococcus aureus (MRSA) obtained from nares of patients and staff of Sokoto state-owned hospitals in Nigeria. GMS Hyg Infect Control 15: Doc25.
23. Joachim A, Moyo SJ, Nkinda L, Majigo M, Mmbaga E, et al. (2017) Prevalence of methicillin-resistant Staphylococcus aureus carriage on admission among patients attending regional hospitals in Dar es Salaam, Tanzania. BMC Res Notes 10: 417.
24. Tamire T, Eticha T, Gelgelu TB (2021) Methicillin-resistant staphylococcus aureus: The magnitude and risk factors among patients admitted to tikur anbessa specialized hospital, Addis Ababa, Ethiopia. Int J Microbiol 2021: 1-7.
25. Radhakrishna M, D'Souza M, Kotigadde S, Saralaya KV, Kotian MS (2013) Prevalence of methicillin resistant Staphylococcus aureus carriage amongst health care workers of critical care units in Kasturba Medical College Hospital, Mangalore, India. J Clin Diagn Res 7: 2697-2700.
26. Legese H, Kahsay AG, Kahsay A, Araya T, Adhanom G, et al. (2018) 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 11: 250.
27. Omuse G, Kariuki S, Revathi G (2012) Unexpected absence of meticillin-resistant Staphylococcus aureus nasal carriage by healthcare workers in a tertiary hospital in Kenya. J Hosp Infect 80: 71-73.
28. Hefzy EM, Hassan GM, Abd El Reheem F (2016) Detection of panton-valentine leukocidin-positive methicillin-resistant Staphylococcus aureus nasal carriage among Egyptian health care workers. Surg Infect 17: 369-375.
29. Hawkins G, Stewart S, Blatchford O, Reilly J (2011) Should healthcare workers be screened routinely for meticillin-resistant Staphylococcus aureus? A review of the evidence. J Hosp Infect 77: 285-289.
30. Joachim A, Moyo SJ, Nkinda L, Majigo M, Rugarabamu S, et al. (2018) 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: 5058390.
31. Wolde W, Mitiku H, Sarkar R, Shume T (2023) Nasal carriage rate of *staphylococcus aureus*, its associated factors, and antimicrobial susceptibility pattern among health care workers in public hospitals, Harar, Eastern Ethiopia. Infect Drug Resist 16: 3477-3486.
32. El Aila NA, Al Laham NA, Ayesh BM (2017) Nasal carriage of methicillin resistant *Staphylococcus aureus* among health care workers at Al Shifa hospital in Gaza Strip. BMC Infect Dis 17: 28.
33. Al-Humaidan OS, El-Kersh TA, Al-Akeel RA (2015) Risk factors of nasal carriage of staphylococcus aureus and methicillin-resistant staphylococcus aureus among health care staffin a teaching hospital in central Saudi Arabia. Saudi Med J 36: 1084-1090.
34. Gebreyesus A, Gebre-Selassie S, Mihert A (2013) Nasal and hand carriage rate of methicillin resistant Staphylococcus aureus (MRSA) among health care workers in Mekelle Hospital, North Ethiopia, Ethiop Med J 51: 41-47.