Egyptian Journal of Medical Microbiology Volume 29 / No.4 / October 2020 1-7 Online ISSN: 2537-0979

ORIGINAL ARTICLE

Nasal Carriage Rate and Antimicrobial Resistance Profiles of Methicillin-Resistant *Staphylococcus Aureus (*MRSA) among Health Care Workers in Tanta University Hospital

[1]Marwa S. Taha*, [2]Eman A. Younis, [1]Eman E. Hegazy
[1]Department of Medical Microbiology & Immunology, Faculty of Medicine, Tanta University, Egypt
[2]Department of public health, Faculty of Medicine, Tanta University, Egypt

Key words:
Methicillin-resistant Staphylococcus aureus (MRSA), Methicillin susceptible Staphylococcus aureus (MSSA), MRSA Nasal Carriage, MRSA antimicrobial resistance profiles

Corresponding Author:
Marwa S. Taha
Department of Medical Microbiology & Immunology, Faculty of Medicine, Tanta University, Egypt
Tel.: 01222253421
Marwa.taha@med.tanta.edu.eg

ABSTRACT

Background*: MRSA is the most commonly known antimicrobial-resistant organism in hospitals worldwide.* ***Objectives****: This study aimed to detect the prevalence of MRSA carriage and its antibiogram among HCWs in Tanta University hospitals to improve infection control and preventive measures.* ***Methodology****: 223 nasal swabs from HCWs were inoculated onto Mannitol salt agar. Detection of MRSA was performed phenotypically using cefoxitin disc diffusion test on Muller–Hinton agar plates. Confirmation of MRSA was done by determining minimum inhibitory concentration (MIC) of oxacillin by using E Test Strips.* ***Results****: Amongst the HCWs, 88 doctors and 135 nurses were randomly selected. The overall frequency of S. aureus nasal carriage was 129/223. Of the 129 S. aureus isolates, (17%) were MRSA. Internal medicine had a high proportion of MRSA positive (36.4%). (63.6%) of the MRSA positive HCWs had a history of using antibiotics during the past 3 months. A high frequency (77.3%) of MRSA was detected among nurses. (50%) HCWs with 5:10 years of working experience were colonized with MRSA.* ***Conclusion****: Multi-drug resistant organisms such as MRSA are a major public health challenge. Colonized HCWs are asymptomatic carriers and can transmit MRSA to vulnerable patients. To control the transmission of MRSA in hospitals, multidisciplinary efforts are recommended to implement and improve infection control policies.*

INTRODUCTION

Staphylococcus aureus has been the causative pathogen most commonly accused of causing human infections over the last century. [1] It is of vast significance due to its ability to cause a wide range of infections as well as its remarkable ability to adapt to various environmental conditions.[2]

Methicillin-resistant Staphylococcus aureus (MRSA) is the most common worldwide known antimicrobial-resistant organism in hospitals.[3] Moreover, MRSA has become increasingly implicated in different forms of hospital-acquired infections such as bacteremia, pneumonia, and surgical wound infections. Worldwide concerns about the rise of MRSA are growing with the epidemiology of infections quickly changing. [4]

MRSA is highly prevalent among health care workers (HCWs), and there is a dynamic spread of strains across the world. The prevalence varies in different countries, with the highest rates of (32–52%) in developing countries.[5] This high prevalence of MRSA among HCWs makes other measures of infection control ineffective. [6]

MRSA infections represent a substantial financial burden, being associated with prolonged hospital stays and occupation of isolation rooms.[7] Moreover, the burden of healthcare-associated MRSA colonization seems to extend beyond the short-term in-hospital setting to long-term care facilities and outpatient care. [8]

The anterior nares are the main reservoir of MRSA. However, other parts of the human body are frequently colonized, such as the hands, skin, axillae, and intestinal tract.[9] In the vast majority of cases, colonized HCWs are generally asymptomatic, however, they remain a potential reservoir of infection for susceptible patients. Expectedly, it has been reported that HCWs have been the source of MRSA outbreaks in several hospitals. [10]

Healthcare workers act more frequently as vectors, rather than being the main sources of MRSA transmission[11]. The most important mode of MRSA transmission is through hand contamination.[12]

So, prompt detection of MRSA is of extreme importance for the proper application of infection control policies to prevent the spread of disease and outbreaks as well as for effective treatment regimens. [13]

Most reviews about MRSA included data from endemic situations and outbreaks. Aside from outbreaks, it is assumed that MRSA rates should be higher when HCWs comply poorly to hand hygiene and contact precautions, as they are not fully aware of the tremendous threat of the bacterial load .[6]

DOI : https://doi.org/10.51429/EJMM29401

However, only a few data are available in the literature on the prevalence of MRSA carriers among HCWs in non-outbreak settings. Thus, the goals of the present study were to document the prevalence of MRSA carriage among HCWs in non-outbreak settings in Tanta university hospitals, Egypt and to identify occupational groups and specialties in the healthcare services associated with higher MRSA exposure. To obtain objective findings that can help in the development of evidence-based control and preventive measures.

METHODOLOGY

A hospital-based cross-sectional study was conducted between February 2019 to December 2019 among the HCWs of Tanta University Hospitals (TUH), Egypt. A total of 223 HCWs including doctors and nurses were enrolled in this study. HCWs were recruited from different Intensive Care Units (ICU) (Anesthesia, Neurosurgery, Pediatrics, Cardiology, Neuropsychiatry, and Internal medicine). The subjects were fully informed about the design and purpose of the study. Informed consent was taken from all participants.

Ethical approval for this study was provided by the Ethics and Research Committee, Faculty of Medicine, Tanta University.

Demographic information included participants' age, gender, and the working department was collected. HCWs, with a history of upper respiratory tract infection, fever, recent nasal surgery, diabetes, use of nasal medications and who were using antibiotics at the time of recruitment were excluded from participating.

Sample collection:

Nasal swabs were collected from anterior nares of the HCWs using sterile cotton swabs (moistened with normal saline). The swab was introduced 2–3 cm in the nasal cavity. Both nostrils were sampled one at a time using the same swab by rotating gently against the inner surface. The swabs were placed in Stuart's transport media (Oxoid, Basingstoke, UK), labeled accurately, and transported to the Microbiology Laboratory for further processing.

Sample processing and Bacteria identification

The Specimens were inoculated onto Mannitol salt agar (MSA) selective media (Oxoid, Basingstoke, UK) and incubated at 37 °C for 24- 48 h. Colonies that were yellow or golden yellow that ferment mannitol were selected and sub-cultured on Nutrient agar (NA) (Oxoid, Basingstoke, UK). The S. aureus isolates were identified phenotypically based on conventional microbiological and biochemical tests. Colonies on NA were subjected to Gram's staining, catalase test, coagulase test, and DNase production on DNA agar. Gram positive cocci that were catalase positive, coagulase positive and DNAse positive were identified as S. aureus.[14]

Identification of MRSA isolates:

Detection of MRSA isolates was performed phenotypically, using cefoxitin disc diffusion test on Muller–Hinton agar plates according to Clinical and Laboratory Standards Institute (CLSI) guidelines .[15] All S. aureus isolates resistant to cefoxitin (30 µg) (Oxoid, Basingstoke, UK) were considered as MRSA. An inhibition zone of 21mm or less around the cefoxitin disk indicated MRSA. S. aureus ATCC 25923 was used for quality control.

Confirmation of MRSA was done by determining minimum inhibitory concentration (MIC) of oxacillin by using E Test Strips (AB bioMérieux, Marcy-l'Étoile, France). The test was performed according to the manufacturer's instructions and interpreted according to CLSI guidelines.[15] MIC for Oxacillin ≥4 was categorized MRSA.

Antimicrobial susceptibility pattern of S. aureus:

Antimicrobial susceptibility of S. aureus isolates was performed by using Kirby–Bauer's disk diffusion method according to CLSI guidelines. Muller–Hinton agar plates were used for susceptibility tests and the standard inoculum was prepared by direct colony suspension in saline and compared with 0.5 McFarland standard turbidity. The interpretation of the results was made based on the CLSI criteria as sensitive, intermediate, and resistant.

The antibiotics discs used in the study were cefoxitin (30 µg), ciprofloxacin (5 µg), mupirocin (10 µg), clindamycin (2 µg), linezolid (30 µg), and trimethoprim-sulfamethoxsazole (1.25/23.75 µg), erythromycin (15 µg), gentamicin (10 µg), penicillin (10Units), teicoplanin (30 µg), tetracycline (30 µg) and vancomycin (30 µg).

RESULTS

Distribution of Sociodemographic Characteristics of Study Participants:

Table 1 shows the distribution of sociodemographic characteristics of the study participants. Amongst the HCWs, 88 doctors and 135 nurses were chosen randomly. Most of the subjects were female (147, 65.9%), and the majority (110, 49.3%) were aged <45 years. Cardio vascular& Internal medicine ICUS had a smaller number (10.3%, 11.2% respectively) of participants, each of the other hospitals ICUS almost had equal proportions of study participants. While Pediatric ICU had the highest number (54, 24.2%) of participants. a majority (110, 49.3%) of the HCWs were reported to have been working in their respective departments for more than ten years. The majority (172, 77.1%) of the participants had received antibiotics within the past three months and near half 120 (57%) occasionally do hand hygiene, while equal proportions either do hand hygiene or never do it (23.8%,19.3%) respectively.

Table 1: General characteristics and demographic data of the study participants:

Characteristic	No (N=223)	Percentage %
Age (years)		
<30	15	6.7
30-44	98	43.9
≥45	110	49.3
Sex		
Male	76	34.1
Female	147	65.9
Profession		
Doctor	88	39.5
Nurse	135	60.5
Department/Ward		
Anesthesia	43	19.3
Neurosurgery	40	17.9
Pediatric	54	24.2
Cardio	23	10.3
Neuropsychiatry	38	17.0
Internal medicine	25	11.2
Duration in health care services (years)		
<5	18	8.1
5-10	95	42.6
>10	110	49.3
History of AB use		
Yes	172	77.1
No	51	22.9
Hand hygiene		
Frequent	53	23.8
Occasional	120	57.0
No	50	19.3

Nasal Carriage Rate of S. aureus and MRSA:

The overall frequency of *S. aureus* nasal carriage among HCWs at the five ICUS was 129/223 (57.8%). Of the 129 *S. aureus* isolates, 22 (17%) were MRSA. therefore, the overall prevalence of MRSA nasal carriage among HCWs was 22/223 (9.8%). (Table 2)

Table 2: Culture result of the nasal swabs of HCWs:

Isolates	Number (223)	Percentage (%)
Coagulase positive staphylococci	**129**	**57.8**
MRSA	22	17
MSSA	107	83
Coagulase negative staphylococci	**34**	**15.2**
No growth	**60**	**27**

Of the total number of HCWs colonized with *S. aureus*, 19 (86.4%) female workers were colonized with the MRSA strain. Internal medicine ICUS had a high proportion of HCWs (8, 36.4%), who tested to be MRSA positive, while anesthesia ICUS (2, 9.1%) had the lowest proportions.

Most (14, 63.6%) of the HCWs who tested to be MRSA positive had a history of using antibiotics during the past three months. A high frequency (17, 77.3%) of MRSA was detected among nurses. While doctors had lower MRSA carriage of (5, 22.7%). eleven (50%) HCWs with five to ten years of working experience in health care services were colonized with MRSA strains. (Table 3)

Table 3: Risk factors associated with nasal carriage of MRSA among study participants:

Characteristic	MRSA		MSSA		P-value
	n=22	%	n=107	%	
Age (years)					.000
<30	0	0	4	3.7	
30-44	6	27.3	37	34.6	
≥45	16	72.7	66	61.7	
Sex					.000
Male	3	13.6	25	23.4	
Female	19	86.4	82	76.6	
Profession					.000
Doctor	5	22.7	22	20.6	
Nurse	17	77.3	85	79.4	
Department/Ward					.000
Anesthesia	2	9.1	20	18.7	
Neurosurgery	3	13.6	15	14.0	
Pediatric	4	18.2	32	29.9	
Cardio	0	0	7	6.5	
Neuropsychiatry	5	22.7	19	17.8	
Internal medicine	8	36.4	14	13.1	
Duration in health care services (years)					**.002**
<5	2	9.1	5	4.7	
5-10	11	50	44	41.1	
>10	9	40.9	58	54.2	
History of AB use					.007
Yes	14	63.6	76	71.0	
No	8	36.4	31	29.0	
Hand hygiene					.000
Frequent	0	0	4	3.7	
Occasional	4	18.2	71	66.4	
No	18	81.8	32	29.9	

Antimicrobial Resistance Pattern.

MRSA isolates showed significantly high resistance to gentamicin, ciprofloxacin, Clindamycin, Cefoxitin, Tetracycline, Erythromycin, and trimethoprim-sulphamethoxazole compared to MSSA isolates (p =0.000).

Only (3, 13.6%) *S. aureus* isolates (MRSA) was resistant to linezolid, while (5, 22.7%) of MRSA isolates showed resistance to mupirocin. All *S. aureus* isolates either (MSSA or MRSA) were susceptible to teicoplanin and vancomycin (Table 4).

Table 4: Resistance pattern among MRSA and MSSA isolates

Antimicrobial drug	MRSA (22) (%)	MSSA (107) (%)	P-value
Penicillin	NA	90 (84.1)	.000
Trimethoprim-sulphamethoxazole	16 (72.7)	7 (6.5)	.000
Ciprofloxacin	19 (86.4)	9 (8.4)	.000
Gentamicin	15 (68.2)	10 (9.3)	.000
Clindamycin	13 (59.1)	6 (5.6)	.000
Tetracycline	7 (4.5)	2 (1.9)	.000
Cefoxitin	22 (100)	0 (0)	.000
Erythromycin	20 (91)	45 (43.3)	.000
Linezolid	3 (13.6)	0 (0)	.000
Teicoplanin	0 (0)	0 (0)	-
Vancomycin	0 (0)	0 (0)	-
Mupirocin	5(22.7%)	3(2.8%)	.000

NA, not applicable

DISCUSSION

Healthcare and community-acquired infections by MRSA are a major concern. For the control of the spread of bacteria to susceptible patients and the spread in hospitals, it is necessary to screen and detect the MRSA carriage status of healthcare workers mainly in the intensive care units.[16]

So this study aimed to determine the prevalence of nasal carriages of MRSA among HCWs of Tanta University Hospitals (TUH) and to detect the antimicrobial-resistant pattern.

The present study revealed the overall *S. aureus* nasal carriage rate among HCWs was (57.8%) and that of MRSA carriage was (9.8%) respectively.

The nasal carriage of *S. aureus* detected in this study is higher than the rate reported by Khatri et al., (18.3%)[17], *Genc, & Arikan* (20.1%)[18], *WU et al.*, (26.1%)[19], Joachim et al**.,** (41.4%) [5] and Al Laham**,** (42.1%)[20]

Regarding MRSA, the prevalence of MRSA carriage among HCWs was (9.8%). our result was curiously lower than reported by Al-Humaidan et al., (18%) [21], Pourramezan et al., **(**22.5%) [22], El Aila et al., (25.5%)[23] and Safdari et al., (31%).[24]

In the present study, the carriage rate of MRSA was lower than the rate has been previously reported from Egypt (14.6%)[25].

On the other hand, lower carriage rates of MRSA than our finding were detected in the studies conducted by Genc, & Arikan (0.37%)[18], Khanal et al. (3.4%),[26] Tiewsoh & Dias (5.55%),[27]and WU et al., (6.1%).[19]

Various studies explained the variation in the prevalence of nasal carriage of *S. aureus* strains by differences in the sample size and the differences in microbiological methods used. Additionally, different levels of adherence to infection control policies may cause these differences.[28]

In the present study, according to HCW professions, MRSA nasal carriage rate was significantly high among nurses (77.3%) compared to doctors (22.7%). Our result was in accordance with results reported by Joachim et al,[5] El Ailae et al [23]and Khanal et al.[26]

The high colonization rate of MRSA strains among nurses may be attributed to their frequent contact with patients.

On the contrary, Chakolwa et al[29] reported the MRSA carriage was comparatively high among doctors (7.1%) followed by nurses (5.8%). Also Rongpharpi et al.[30] found The MRSA carriage was higher among doctors than nurses (25% and 22.86%, respectively).

Regarding the potential risk factors associated with the MRSA carriage rate, it is reported that sociodemographic characteristics (such as age, gender, occupation, length of medical service, history of antibiotic use, and hand hygiene) may affect the colonization rate of S. aureus. [21,31]

In our study, there was a significant difference in the carriage rate of *S. aureus* among HCWs with the tested risk factors. This finding was not in agreement with Chakolwa et al,[29] who did not found any significant difference in the carriage of *S. aureus* among HCWs with the risk factors tested. Additionally, Pathare et al, found gender, underlying co-morbidities, and recent antibiotic use were not significantly associated with S. aureus carriage.[32]

Since most of the MRSA strains spread through contaminated hands, it is reported that frequent and correct handwashing can reduce the risk of HCWs colonization with MRSA.[33]

In the present study, we found a significant difference in MRSA carriage between HCWs who frequently wash hands and those who rarely do so after patients contact. This is contrary to the findings reported by Joachim et al,[5] who reported no significant difference in MRSA carriage between HCWs who frequently wash hands and those who rarely do so after patient contact.

The rate of MRSA carriage varies between hospital wards. The highest MRSA carriage rate was found in internal medicine ICU and Neuropsychiatry ICU 36.4% and 22.7% respectively.

In the current study, antimicrobial susceptibility pattern of the *s.aureus* isolates, a high proportion (84.1%) were resistant to penicillin. MRSA isolates revealed a significantly high resistance to gentamicin, ciprofloxacin, Clindamycin, Cefoxitin, Tetracycline, Erythromycin, and trimethoprim-sulphamethoxazole compared to MSSA isolates.

Our findings are in accordance with Tiewsoh and Dias.[34] who found MRSA isolates showed a significantly high resistance to compared to MSSA isolates.

Moreover, Joachim et al,[5] recorded significantly higher levels of resistance among MRSA isolates to kanamycin, gentamicin, ciprofloxacin and trimethoprims sulphamethoxazole compared with those detected for MSSA isolates

In the current study, (13.6%) MRSA isolates were resistant to linezolid, while (22.7%) of MRSA isolates and (2.8%) MSSA showed resistance to mupirocin. All S.aureus either MRSA or MSSA were susceptible to teicoplanin and vancomycin.

On the other hand, Joachim et al,[5] reported that the resistance rate of MRSA isolates to mupirocin was low (10.2%) while all the MRSA isolates were susceptible to linezolid. Furthermore, lower mupirocin resistance has been previously reported from Egypt (3.3%) [35]. In the other hand, Boncompain et al,[36] reported all MRSA strains isolated were susceptible to mupirocin.

In the current study, the sensitivity pattern of all S. aureus either MRSA or MSSA to teicoplanin detected was inconsistent with findings reported by Chakolwa et al.[29]

In accordance with our study and Boncompain et al and Pant& Sharma found all S. aureus isolates were sensitive to vancomycin.[36,37]

CONCLUSION

Multi-drug resistant organisms such as MRSA are a major public health challenge. Colonized HCWs are asymptomatic carriers and can transmit MRSA to vulnerable patients. To control the transmission of MRSA in hospitals, multidisciplinary efforts are recommended to implement and improve infection control policies.

Conflicts of interest:

The authors declare that they have no financial or non financial conflicts of interest related to the work done in the manuscript.

- Each author listed in the manuscript had seen and approved the submission of this version of the manuscript and takes full responsibility for it.
- This article had not been published anywhere and is not currently under consideration by another journal or a publisher.

REFERENCES

1. Hussein NR, Assafi MS, and Ijaz, T. Methicillin-resistant Staphylococcus aureus nasal colonization amongst healthcare workers in Kurdistan Region, Iraq. Journal of Global Antimicrobial Resistance .2017; 9:78-81.
2. Lakhundi S and Zhang K. Methicillin-resistant Staphylococcus aureus: molecular characterization, evolution, and epidemiology. Clinical microbiology reviews. 2018; 12; 31(4):e00020-18.
3. Dulon M, Peters C, Schablon, A and Nienhaus, A. MRSA carriage among healthcare workers in non-outbreak settings in Europe and the United States: a systematic review. *BMC infectious diseases*.2014; *14*(1), 363.
4. Mohamed N, Timofeyeva Y, Jamrozy D, Rojas E, et al. Molecular epidemiology and expression of capsular polysaccharides in *Staphylococcus aureus* clinical isolates in the United States. PLoS ONE 2019; 14(1): e0208356.
5. Joachim A, 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. International journal of microbiology, 2018, Article ID 5058390, 7 pages
6. Albrich WC and Harbarth S. Health-care workers: source, vector, or victim of MRSA? Lancet Infectious Diseases 2008; 8(5), 289-301.
7. Henares D, Brotons P, Buyse X, Latorre I et al. Evaluation of the Eazyplex MRSA Assay for the Rapid Detection of Staphylococcus Aureus in Pleural and Synovial Fluid. international journal of infectious disease 2017; 59:65-68.
8. Dulon M, Hamann F, Peters C, Schablon A, et al. MRSA prevalence in European healthcare settings: a review. BMC Infect Dis 2011; 11:138.
9. Acton DS, Plat-Sinnige MJ, van Wamel W, de Groot N, et al. Intestinal carriage of Staphylococcus aureus: how does its frequency compare with that of nasal carriage and what is its clinical impact. Eur J. Clin Microbiol Infect Dis 2009; 28:115–127
10. Vonberg RP, Stamm-Balderjahn S, Hansen S, Zuschneid I, et al. How often do asymptomatic healthcare workers cause methicillin-resistant *Staphylococcus aureus* outbreaks? A systematic evaluation. Infection Control & Hospital Epidemiology 2006 ; 27, (10): 1123–1127
11. Hawkins G, Stewart S, Blatchford O, and Reilly J. Should healthcare workers be screened routinely for methicillin-resistant Staphylococcus aureus? A review of the evidence. J Hosp Infect 2011; 77:285–289.
12. Cimolai N. The role of healthcare personnel in the maintenance and spread of methicillin-resistant Staphylococcus aureus. J Infect Public Health 2008; 1:78–100.
13. Chen C, Zhao Q, Guo J, Li Y, et al. Identification of methicillin-resistant Staphylococcus aureus (MRSA) using simultaneous detection of mecA, nuc, and femB by loop-mediated isothermal amplification (LAMP).Current microbiology 2017;74(8):965-971.

14. Cheesbrough M. District laboratory practice in tropical countries, vol. 2. 2nd ed. New York: Cambridge University Press; 2006.
15. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Sixth Informational Supplement. Document M100-S26. 26th ed. Wayne, PA: Clinical and Laboratory Standards Institute; 2016.
16. Malini J, Shruti AH, Padmavathy M, Umapathy BL, et al. Methicillin-resistant Staphylococcus aureus carriage among the health care workers in a tertiary care hospital. Journal of Clinical & Diagnostic Research. 2012;6(5):791–3.
17. Khatri S, Pant N D, Bhandari R, Shrestha K L et al. Nasal carriage rate of methicillin-resistant staphylococcus aureus among health care workers at a tertiary care hospital in Kathmandu, Nepal. Journal of Nepal Health Research Council.2017;*15*(1), 26-30.
18. Genc O and Arikan I. The relationship between hand hygiene practices and nasal Staphylococcus aureus carriage in healthcare workers. *La Medicina del Lavoro*.2020; *111*(1), 54-62.
19. Wu T H, Lee CY, Yang HJ, Fang Y P, Chang Y F, et al. Prevalence and molecular characteristics of methicillin-resistant Staphylococcus aureus among nasal carriage strains isolated from emergency department patients and healthcare workers in central Taiwan. Journal of Microbiology, Immunology, and Infection.2019;*52*(2), 248-254.
20. Al Laham N**.** Detection and Antibiotic Resistance Pattern of Staphylococcus aureus and MRSA Isolated from Healthcare Workers Nares at Gaza Hospitals, Palestine. The International Arabic Journal of Antimicrobial Agents.2016; 5(4).
21. Al-Humaidan OS, El-Kersh TA, and 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 Journal. 2015 ;36(9):1084-90.
22. Pourramezan N, Ohadian Moghadam S and Pourmand MR. Methicillin-resistant *Staphylococcus aureus* tracking spread among health-care workers and hospitalized patients in critical wards at a university hospital, Tehran, Iran. New Microbes New Infect. 2018; 16;27:29-35.
23. El Aila N., Al Laham N A and Ayesh B M. Nasal carriage of methicillin-resistant Staphylococcus aureus among health care workers at Al Shifa hospital in Gaza Strip. BMC infectious diseases.2017; 17(1), 28.
24. Safdari H, Aryan E, Sadeghian H., Shams, SF, and Aganj, M. Frequency of methicillin-resistant Staphylococcus aureus (MRSA) in nose and cellular phone of medical and non-medical personnel of emergency departments of Ghaem hospital in Mashhad city. *Clinical Epidemiology and Global Health*;2020.
25. Malek, MM and Abo-Alella, DA. Methicillin-Resistant Staphylococcus Aureus Nasal Carriage among Health Care Workers in Surgery Department at a Tertiary Care Hospital in Egypt. Egyptian journal of Medical Microbiology. 2019:28(7);115-120.
26. Khanal R, Sah P, Lamichhane P, Lamsal A, et al. Nasal carriage of methicillin-resistant Staphylococcus aureus among health care workers at a tertiary care hospital in Western Nepal. Antimicrobial Resistance and Infection Control. 2015;4:39.
27. Tiewsoh JBA and Dias M. Screening of methicillin-resistant *Staphylococcus aureus* in healthcare workers and students and its susceptibility to mupirocin in a tertiary care teaching hospital in South India. J Lab Physicians. 2017 ;9(4):239-242.
28. Sassmannshausen R, Deurenberg R H, Köck R, Hendrix R, et al. MRSA prevalence and associated risk factors among health-care workers in non-outbreak situations in the Dutch-German EUREGIO. Frontiers in microbiology.2016;7, 1273.
29. Chakolwa G, Samutela M T, Kwenda G, Mulundu G et al. Carriage rate and antimicrobial resistance profiles of Staphylococcus aureus among healthcare workers at a large tertiary referral hospital in Lusaka, Zambia. Scientific African.2019; *5*, e00105.
30. Rongpharpi SR, Hazarika N K, and 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. Journal of clinical and diagnostic research.2013; *7*(2), 257.
31. Sollid JU, Furberg AS, Hanssen AM, and Johannessen M. Staphylococcus aureus: determinants of human carriage. infection, Genetics, and Evolution.2014;21: 531-541
32. Pathare NA, Asogan H, Tejani S, Al Mahruqi G, et al. Prevalence of methicillin-resistant Staphylococcus aureus [MRSA] colonization or carriage among health-care workers. Journal of Infection and Public Health.2016; *9*(5), 571-576.
33. World Health Organization, Transmission of Pathogens by Hands, WHO Guideline on Hand Hygiene in Health Care; First Global Patient Safety Challenge Clean Care is Safer Care, Book Shelf, World Health Organization, Geneva, Switzerland, 2009.
34. Tiewsoh JBA and Dias M. Screening of methicillin-resistant Staphylococcus aureus in

healthcare workers and students and its susceptibility to mupirocin in a tertiary care teaching hospital in South India. Journal of Laboratory Physicians. 2017;9(4):239-242.

35. Shalaby MM., & El Shahat, DA. Resistance to Mupirocin among Methicillin Resistant Staphylococcus Aureus Isolates from Community Acquired Infections, Hospital Acquired Infections, and colonized Health Care Workers. Egyptian Journal of Medical Microbiology .2018:27(2);65-69.
36. Boncompain CA, Suárez CA, and Morbidoni HR**.** Staphylococcus aureus nasal carriage in health care workers: First report from a major public hospital in Argentina. *Revista Argentina de microbiologia*.2017; *49*(2), 125-131.
37. Pant ND and Sharma M**.** Carriage of methicillin-resistant Staphylococcus aureus and awareness of infection control among health care workers working in intensive care unit of a hospital in Nepal. Brazilian Journal of Infectious Diseases. 2016; *20*(2), 218-219.