https://doi.org/10.15218/zjms.2018.053

Prevalence of nasal carriage rate for methicillin-resistant *Staphylococcus aureus* and its antibiotic susceptibility profiles in health care workers at Nanakaly Hospital, Erbil, Iraq

Received: 24/5/2017 Accepted: 11/9/2017

Nasik Shawkat Dogramachy*

Abstract

Background and objective: Healthcare workers have been identified as the source of infection in many outbreaks of methicillin-resistant *Staphylococcus aureus* in the hospital environment. Therefore, we aimed to demonstrate the prevalence of nasal carriage of methicillin-resistant *Staphylococcus aureus*and their antibiotic resistance patterns among healthcare workers.

Methods: A cross-sectional study was carried out on a total of 94 healthcare workers at Nanakaly hospital. Nasal swabs were collected and cultured on Mannitol Salt Agar. *Staphylococcus aureus* was identified by Gram's stain, catalase test, and coagulase test. *Staphylococcus aureus* isolates were confirmed as methicillin-resistant *Staphylococcus aureus* using cefoxitin (30 µg) disc diffusion test. Antibiotic susceptibility was performed according to the Kirby-Bauer disc diffusion method.

Results: A total of 23 (24.5%) healthcare workers were nasal carrier for *Staphylococcus aureus*, and the overall methicillin-resistant *Staphylococcus aureus* carriage rate was 8.5%. There was no statistically significant difference between the gender (P = 0.29), age (P = 0.29), and occupations (P = 0.721) and the nasal carriage of methicillin-resistant *Staphylococcus aureus* and methicillin-sensitive *Staphylococcus aureus*. All isolates of methicillin-resistant *Staphylococcus aureus* and methicillin-sensitive *Staphylococcus aureus* were sensitive for linezolid and mupirocin. The highest resistance rate for both erythromycin and clindamycin (75%) was noted among the methicillin-resistant *Staphylococcus aureus*strains, while the highest resistance rate in methicillin-sensitive *Staphylococcus aureus* strains was penicillin (72.5%), erythromycin (20%) and ciprofloxacin (13.3%).

Conclusion: Healthcare workers were the potential colonizers of methicillin-resistant *Staphylococcus aureus*. So regular screening of the healthcare workers is one of the effective methods to reduce and control of methicillin-resistant *Staphylococcus aureus* in any health care facility and applying the appropriate preventive measures will prevent transmission of methicillin-resistant *Staphylococcus aureus*to other contact patients.

Keywords: Methicillin-resistant *Staphylococcus aureus*; Healthcare workers; Antibiotic susceptibility profiles; Erbil.

Introduction

Staphylococcus aureus (*S. aureus*) is a major human pathogen that causes the abroad range of serious community-acquired and nosocomial diseases in humans, from minor skin infections to severe infections such as septicemia.[1,2] The widespread use of antibiotics has led to the emergence of strains that systematically acquire multiple resistance genes.[3] In the 1940s, penicillin was introduced for the treatment of infection; as early as 1942, strains of *S. aureus* resistant to penicillin had been detected in hospitals. Within two decades, up to 80% of both hospital and community-acquired *S. aureus* isolates were penicillin resistant. The introduction of methicillin in 1961 was rapidly followed by reports of methicillin-resistant in

* Department of Microbiology, College of Medicine, Hawler Medical University, Erbil, Iraq.

https://doi.org/10.15218/zjms.2018.053

S. aureus.[4] Today, methicillin-resistant *Staphylococcus aureus* (MRSA) strains are found worldwide, and it is resistant to all other beta-lactam antibiotics including penicillins, cephalosporins, and cephamycins except ceftaroline. Additionally, MRSA is often resistant to other classes of antimicrobials, including aminoglycosides, macrolides, and quinolones. Thus, MRSA is not only methicillin-resistant but is also multidrug-resistant.[5] Most *S. aureus* infections occur in persons who are colonized with the organism. *S. aureus* carriage has long been known to be one of the most strongly associated risk factors for subsequent infection.[6,7] Elegantly designed studies performed during the early 20th century identified the anterior nares as the most consistent site of staphylococcal colonization.[8,9] Presence of *S. aureus* nasal colonization can provide an indication of a higher risk for subsequent infection, including with MRSA.[10,11] The other risk factor for MRSA infection in the inpatient setting is a compromised immune system. Those most at risk for infection are infants,[12] the elderly,[13] the chronically ill,[14] burn survivors, organ transplants recipients,[12] cancer patients receiving chemotherapy agents, steroid users,[15] diabetic patients, intravenous drug users, and those with AIDS.[16] Additional risk factors for hospital-acquired (HA-MRSA) infection include the length of stay in the hospital, exposure to antibiotics,[17] and exposure to people infected with MRSA.[18] The role of healthcare workers (HCWs) in the nosocomial transmission of MRSA has been widely reported and discussed with many studies citing HCWs as a source of nosocomial transmission of MRSA in developing countries.[19] Although efforts to prevent MRSA transmission and infection in the most developed countries receive major research funding, the extent of the MRSA problem remains largely unknown in resource-poor regions. Moreover, surveillance systems to guide interventions require expertise and resources, which are very limited in developing countries, where social and health care system deficiencies such as overcrowding and understaffing result in a lack of infection control practices. For an integrated worldwide control of MRSA, studies to appraise the prevalence and profile of *S. aureus* in developing nations are mandatory.[20] Estimates of HCWs carriage from the worldwide literature vary widely depending on the country, hospital specialty and setting (endemic, non-endemic or outbreak). Albrich et al[21] provided data from 41 studies which studied HCWs carriage rates for *S. aureus* and MRSA. They found 23.7% *S. aureus* carriage among 10 589 HCWs. In 127 investigations, the average MRSA carriage rate was 4.6%. Hawkins et al.[22] from a literature review identified 18 papers published between April 2006 and March 2010 on carriage rates of HCWs ranging from 2% to 15%.In the Middle East countries (including Saudi Arabia, Kuwait, Lebanon, and Palestine), 0-13.2% MRSA nasal carriage rates have been observed.[23-28] In Iraq, most published data are about clinical and patient's samples or combined patients with HCWs or in general population other than HCWs. In a study carried out by Habib et al.[29] from Kurdistan region –Duhok city on 489 students aged between16 to18 years old, a total of 90 out of 489 (18.4%) of them were found to be colonized by *S. aureus*. Only 10 (2.04%) of the students were found to be MRSA carrier. In another study carried out by Husein et al.[30] in Kurdistan region 508 students from secondary schools were included in this study, both urban area of Duhok (N = 239) and surrounding rural areas in three districts; Amede, Akre, and Zakho (N = 270) were included. It was found that the frequency of overall *S. aureus* nasal carriage was 17.75% and the overall MRSA colonization rate among the entire studied population was 1.9%. Additionally, another study carried out by Abed et al.[31] from Al- Mustansiriyah University in Bagdad city. In this study 113,

https://doi.org/10.15218/zjms.2018.053

nasal swaps of students from the Department of Biology were collected. The nasal carriage rate for *S. aureus* was 37%. Furthermore, a study from Baghdad University carried out by Al-Dhabi et al.[32] A total of 250 nasal swabs (175 patients and 75 HCWs at Al- Kadhamia teaching Hospital and Al- Numan Hospital) were screened for *S. aureus*. A total of 106 individuals (42.4%) were identified as nasal carriers, and overall of MRSA carriage rate was 40%. Nanakaly Hospital for Blood Diseases is one of the reference hospitals in Erbil city for Haematology and Oncology patients. Majority admitted patients are cancer patient receiving chemotherapy, and they are more susceptible to the nosocomial infections; so identification and isolation of MRSA carrier in HCWs is essential not only for choosing appropriate antibiotic therapy but also for infection control policies. In this study, we investigated the prevalence of nasal carriage of MRSA and their antibiotic resistance patterns among HCWs at Nanakaly Hospital, Erbil.

Methods

Sample & Data Collection:
A cross-sectional study was conducted in Nanakaly Hospital for Haematology and Oncology in Erbil city from November 2014 to February 2015. All HCWs including (doctors, nurses, laboratory technicians, no - medical personnel) were recruited in the study. After clarifying the aim of the study and obtaining verbal consent; the anonymous questionnaire was prepared for data collection including socio-demographic factors such as gender, age, and occupation. Specimens were taken from the participants in the following way; a single culture swab was moisture in normal saline and then gently rotated inside both nares. Cultured swabs were immediately sent to the laboratory and processed within 1 hour of sampling.

Culture and Identification: Swabs were inoculated in Mannitol Salt Agar (MSA) (LAB 007, UK) within one hour of collection and incubated at 35°C for 24–48 hours. Those colonies that are mannitol fermenters (golden or cream color on MSA) were subcultured on 5% Sheep Blood Agar (LAB 007, UK). Incubated as above and examined after 24 hours. Growth was identified as *S.aureus* by standard methods (Gram's stain, catalase test, and coagulase test).[34] The methicillin susceptibility of *S. aureus* was determined by cefoxitin disk (BD disk) using the disk diffusion test following manufacturer's instructions and the revised 2014 Clinical and Laboratory Standards Institute (CLSI) guidelines.[35] The isolates were considered MRSA if the diameter of the zone of inhibition was 21mm or less.[35] All MRSA isolates were frozen at –70 ºC for additional testing of organism characteristics.

Antimicrobial Susceptibility Testing: Disk diffusion susceptibility tests were applied according to CLSI recommendations.[35] The MRSA and MSSA isolates were tested by disk diffusion susceptibility method against the following antibiotics: penicillin (10unit), gentamycin (10µg), erythromycin (15 µg), ciprofloxacin (5µg), co-trimoxazole (25µg), clindamycin (2µg) tetracycline (30 µg), mupirocin (200µg) and linezolid (10 µg)according to CLSI recommendations.[35]

Ethical Considerations: Informed oral consent was obtained from all study samples before specimen collection. The study was approved by the Ethics Committee of the College of Medicine, Hawler Medical University.

Statistical Analyses: Data were analyzed using the statistical package for the social sciences (version 19.0). The categorical data were compared using the Chi-square test or Fisher's exact test. A *P* value of <0.05 was regarded as statistically significant.

Results

MRSA nasal carriage rate among HCWs
A total of 15 (16%) methicillin-sensitive *Staphylococcus aureus* (MSSA) and 8 (8.5%) MRSA isolates were recovered

https://doi.org/10.15218/zjms.2018.053

from the 94 nasal swab specimen cultures of HCWs. The overall nasal carriage rate of *S.aureus* was 23(24.5%) as shown in Table 1.

Association of nasal carriage rates with socio-demographic characteristics

The age of HCWs ranged from 20 to 59 years; 41 (43.6%) were males, and 53 (56.4%) were females, with the male to female ratio of 1:.29. Out of MRSA samples, 62.5% were males, and 37.5% were female. Among the age group 37.5%, 37.5% of them were 30-39 and 40-49 years old respectively, and 50% of them were physicians (clinical and lab), 37,5% were nurses, and 12% were cleaning personnel. While among MSSA cases, 60% were male and 40% were female, and 60% of them were 20-29 years old, while only 6.7% were 50-59 years old. Furthermore, 53.3% of MSSA cases were nurses, and 20% were physicians (clinical and lab). The study showed that there was no statistically significant difference between the gender (*P* = 0.29), age (*P*=0.29), and occupation (*P* = 0.721) between those with nasal carriage of MRSA and MSSA as shown in Table 2.

Table 1: MRSA and MSSA nasal carriage rate among HCWs.

Nasal carriage	Isolates	No(%)
Positive	*S. aureus*	23(24.5%)
	MSSA	15 (16%)
	MRSA	8 (8.5 %)
Negative	-	71 (75.5 %)
Total sample	-	94(100%)

MSSA: Methicilline sensitive *S.aureus*
MRSA: Methicilline resistant *S.aureus*

Table 2: Association of nasal carriage rates with socio-demographic characteristics.

Variable	MSSA(n=15) (%)	MRSA (n=8) (%)	*P* value
Sex			
Male	9(60)	5(62.5)	0.290
Female	6(40)	3(37.5)	
Total	15(100)	8(100)	
Age group			
20- 29	9(60)	2 (25)	0.290
30- 39	3(20)	3 (37.5)	
40- 49	2(13.3)	3(37.5	
50 -59	1(6.7)	0 (0)	
Total	15(100)	8(100)	
Occupation			
Physician (clinical)	2(13.3)	3(37.5)	0.721
Physician (lab)	1(6.7)	1(12.5)	
Nurse	8(53.3)	3(37.5)	
Lab worker	1(12.5)	0(0)	
Cleaning Personnel	3(20)	1(12.5)	
Total	15(100)	8(100)	

MSSA: Methicilline sensitive *S.aureus*
MRSA: Methicilline resistant *S.aureus*

https://doi.org/10.15218/zjms.2018.053

Antibiotic susceptibility profile of *S. aureus* samples

The *in vitro* antibiotic sensitivity profiles for the eight isolates of MRSA and the 15 isolates of MSSA carriers are shown in Figure 1 and 2. The Figures show that all isolates of MRSA and MSSA were sensitive for linezolid and mupirocin. Rates of resistance in MRSA and MSSA to antimicrobial agents were chloramphenicol, 37.5.% and 0%; ciprofloxacin 25%, 13.3%, clindamycin, 75% and 6.7%; erythromycin,75% and 20%; gentamicin 12.5, 0%, penicillin 100%, 73.3%, rifampicin, 12.5%, 0%; trimethoprim-sulfamethoxazole, 12.5% and 6.7%, and tetracycline 25%, 6.7% respectively. The highest resistance rate for both erythromycin and clindamycin 75%) were noted among the MRSA strains, while the highest resistance rate for MSSA strains to penicillin 73.3%, erythromycin 20% and ciprofloxacin 13.3 were observed.

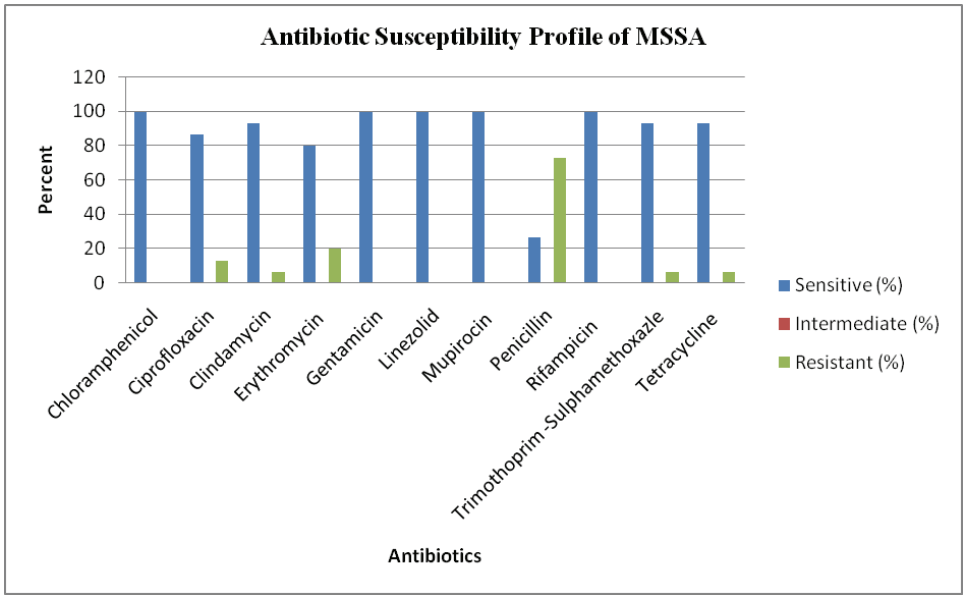

Figure1: Antibiotic susceptibility profile of methicilline sensitive *S. aureus*.

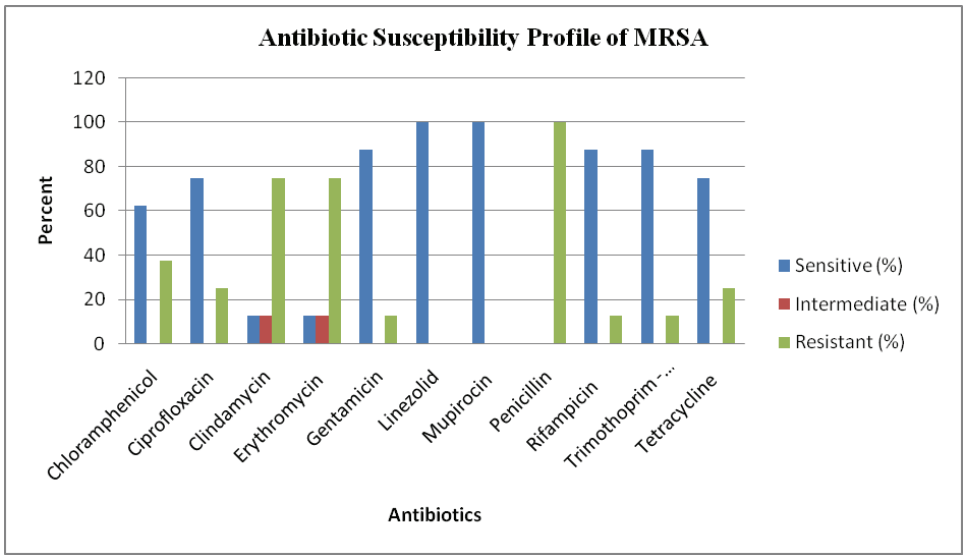

Figure 2: Antibiotic susceptibility profile of methicilline resistant *S. aureus*.

https://doi.org/10.15218/zjms.2018.053

Discussion

MRSA accounts for 20% to 80% of nosocomial infections worldwide.[36] In most of the cases, these patients are colonized before infection.[37] Surveillance of MRSA colonization among inpatient populations and HCWs has dramatically reduced the number of MRSA-associated nosocomial infections.[38] Therefore, measurement of colonization of the HCWs is one of the effective methods to reduce and control MRSA in any health care facility. We found that 24.5% of HCWs were the nasal carrier for *S.aureus* and the overall MRSA carriage rate was 8(8.5%) as shown in Table1. In Iraq, reported data about the prevalence of nasal carriage of *S.aureus* and MRSA among health workers specifically are very scarce. Recently one study from Duhok city, Kurdistan region was reported by Hussein et al.[39] In this study a total of 182 HCWs with different occupations and working in different hospital units as well as 198 on-HCWs were recruited. Nasal carriage of *S. aureus* was 22.5% in HCWs and 18.7% in on-HCWs. Our result was in agreement with this result regarding *S.aureus* carriage rate while overall MRSA carriage rate was 13.7% in the same study which was higher than our finding. Differences in the prevalence of nasal carriage of MRSA strains may be due in part to differences in the method which used for identification of MRSA. On the other hand, our result was consistent with the finding of Muhammed et al. study[40] from Karbala University, in which 100 healthy students from the third and fourth stages of the College of Medicine who had internship program in hospitals during the Summer were screened, and *S.aureus* and MRSA colonization rate were detected among them as 20% and 8%, respectively. Several studies worldwide have reported the rate of nasal carriage of *S. aureus* strains and MRSA among HCWs. Our results were internationally consistent with these veral studies from Iran,[41-43] which reported the MRSA rate between 5.3% and 13.9% among HCWs. Also in another study from Jordan,[44] the overall prevalence of MRSA nasal carriage was 7.8% (ranging from 4.3% in adults to 10.1% in HCWs). Additionally, systemic search for literature which conducted in MEDLINE and EMBASES databases was made by Dulon et al.,[45] 31 studies were included in this review reported non-outbreak carriage rates MRSA in HCWs from zero to 15%. On the other hand, our results regarding MRSA carriage rate were significantly higher than some reported results by authors from Turkey[46-48] 1.8%, 4.7%. In contrast to another study from Gaza strip,[49] the MRSA carriage rate was very high 25.5% compared to our result. These differences can be explained by variations in microbiological methods sampling techniques, culture, and method of MRSA identification, local infection control standards and the local prevalence of MRSA. Our study showed that HCWs are potential colonizers of MRSA however; we need more surveillance data about MRSA colonization and their molecular typing in nosocomial setting to confirm these results. HCWs have been addressed as the source of infection in many outbreaks of MRSA in hospitals.[50] In our study, we found that MSSA carriage rate was highest among Nurses 53.3%, While MRSA carriage rate was highest among physicians 50% followed by Nurses 37.5%. In many international studies MSSA and MRSA were determined to be associated with risk factors like age, gender, and occupation [51] however; in this study because of small size sample; we found that these variables were not considered the risk factor for nasal carriage rate of MRSA and MSSA. Antimicrobial resistance among nosocomial pathogens is a significant problem in many countries with severe consequences including increased medical costs, morbidity, and mortality of patients.[52] Since the emergence of *S. aureus* strains with resistance to penicillin and methicillin in 1942 and 1961 respectively,[53] it has become a well-known

https://doi.org/10.15218/zjms.2018.053

etiologic agent of a wide variety of infections and has assumed increasing importance internationally as a cause of both nosocomial and community-acquired infections.[54] MRSA strains are also more likely to be resistant to other antimicrobial agents than are methicillin-susceptible *S. aureus* isolates. From a study carried out by Diekema et al.[55] rates of resistance to representatives of 8 antimicrobial classes are delineated (chloramphenicol, ciprofloxacin, clindamycin, erythromycin, gentamicin, rifampicin, trimethoprim-sulfamethoxazole, tetracycline). Latin American MRSA isolates were resistant to a median of 6 antimicrobial classes, whereas US and Canadian strains demonstrated resistance to a median of three additional antimicrobial classes. Agents for which there were substantial regional differences in resistance included chloramphenicol (57.9% resistant in Latin America *vs.*<10% resistant in all other regions), rifampin (range, 4.9% resistant in Canada to 44.4% in Europe), tetracycline (14.8% and 15.6% resistant in the United States and Canada, respectively, *vs.* 82% resistant in the Western Pacific region), and gentamicin (range, 25.9% resistant in Canada to 91.2% resistant in Latin America). High levels of resistance to erythromycin, clindamycin, and ciprofloxacin were found among MRSA in all regions. The findings of this study were consistent with our high resistance rates of MRSA to clindamycin, erythromycin, tetracycline, and chloramphenicol. On the other hand, all the strains of S. Aureus including MSSA and MRSA strains isolated from nasal swaps were susceptible to linezolid and mupirocin probably, because these antibiotics are not available in Nanakaly Hospital and not used for eradication or treating of infections by MRSA. These data suggest that we can use mupirocin to eradicate HCWs colonizer with MRSA and linezolid as the second-line choice for treating MRSA infections. Although the small size sample of this study hinders its application to other hospitals population in Erbil, particularly well-designed larger multicenter studies, molecular basis, should be carried out to confirm these results. Moreover, further studies including vancomycin-intermediate *Staphylococcus aureus* (VISA) and vancomycin-resistant *Staphylococcus aureus* (VRSA) will be useful to gain insights into the antibiotic-resistant profile of *S. aureus*, and MRSA isolates from HCWs and health residences.

Conclusion

We demonstrated that HCWs were the potential colonizers of MRSA. The carriage rate of *S. aureus* and MRSA is highest among physicians and nurses respectively. So our data suggested and recommended to introduce routine MRSA screening of HCWs part of a suite of infection control measures. Furthermore, continuous laboratory-based surveillance and improvement of hygiene standards in hospitals will be helpful to prevent possible transmission of MRSA in healthcare facilities.

Competing interests

The author declares no competing interests.

References

1. Tokajian S. New epidemiology of Staphylococcus aureus infections in the Middle East. Clin Microbiol Infect 2014; 20(7):624–8.
2. David MZ, Daum RS. Community-associated methicillin-resistant Staphylococcus aureus: epidemiology and clinical consequences of an emerging epidemic. Clin Microbiol Rev 2010; 23:616–87.
3. Mohajeri P, Izadi B, Rezaei M, Farahani A. Frequency distribution of hospital-acquired MRSA nasal carriage among hospitalized patients in West of Iran. Jundishapur J Microbiol 2013; 6(6):9076.
4. Appelbaum PC. MRSA—the tip of the iceberg. Clin Microbiol Infect 2006; 12(2):3–10.
5. Iyer A, Kumosani T, Azhar E, Barbour E, Harake S. High incidence rate of methicillin-resistant Staphylococcus aureus (MRSA) among healthcare workers in Saudi Arabia. J Infect Dev Ctries 2014; 8(3):372–8.
6. Von EC, Becker K, Machka K, Stammer H, Peter G. Nasal carriage as a source of Staphylococcus aureus bacteremia. N Engl J

Med 2001; 344:11–6.
7. Miles AA, Williams REO, Clayton CB. The carriage of Staphylococcus aureus in man and its relation to wound infection. J Pathol Bacteriol 1944; 56:513–24.
8. Williams REO. Skin and nose carriage of bacteriophage types of S. aureus. J Pathol Bacteriol 1946; 58:259–68.
9. Gillespie EH, Devenish EA, Cowan ST. Pathogenic staphylococci: their incidence in the nose and on the skin. Lancet 1939; 2:870–3.
10. Kluytmans J, Van Belkum A, Verbrugh H. Nasal carriage of Staphylococcusaureus: epidemiology, underlying mechanisms, and associated risks. Clin Micro Rev 1997; 10:505–20.
11. Yu VL, Goetz A, Wagener M. Staphylococcus aureus carriage and infection in patients on hemodialysis. N Engl J Med 1986; 315:91–6.
12. Durai R, Ng PC, Hoque H. Methicillin-resistant Staphylococcus aureus: an update. AORN J 2010; 91(5):599–606.
13. Matouskova I, Janout V. Current knowledge of methicillin resistant Staphylococcus aureus and community-associated methicillin-resistant Staphylococcus aureus. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub 2008; 152(2):191–202.
14. Herman RA, Kee VR, Moores KG, Ross MB. Etiology and treatment of community-associated methicillin-resistant Staphylococcus aureus. Am J Health Syst Pharm 2008; 65(3):219–25.
15. Heymann DL. Control of communicable diseases manual. 19thed. Washington, DC: American Public Health Association; 2008.
16. Archer GL. Staphylococcus aureus: a well-armed pathogen. Clin Infect Dis 1998; 26(5):1179–81.
17. Tacconelli E, De Angelis G, Cataldo MA, Pozzi E, Cauda R. Does antibiotic exposure increase the risk of methicillinresistant Staphylococcus aureus (MRSA) isolation? A systematic review and meta-analysis. J Antimicrob Chemother 2008; 61(1):26–38.
18. Nelson KE, Williams CM. Infectious disease epidemiology: theory and practice. 2nd ed. Sud-bury, MA: Jones and Bartlett Publishers; 2007.
19. Ahmed MO, Elramalli AK, Amri SG, Abuzweda AR, Abouzeed YM. Isolation and screening of methicillin-resistant Staphylococcus aureus from health care workers in Libyan hospitals. East Mediterr Health J 2012; 8(1):37–41.
20. Conceição T, Santos SI, De Lencastre H, Aires-DM. Staphylococcus aureus nasal carriage among patients and health care workers in Sao Tome and Prıncipe. Microb Drug Resist 2014; 20 (1):57–66.
21. Albrich WC, Harbarth S. Health-care workers: soruce, vector, or victim of MRSA? Lancet Infect Dis 2008; 8:289–301.
22. Hawkins G, Stewart S, Blachtford O, Reilly J. Should healthcare workers screened routinely for methicillin-resistant Staphylococcus aureus? A review of the evidence. J Hospital Infect 2011;77:285–9.
23. Islam SI, Moore C. Prevalence of methicillin-resistant Staphylococcus aureus and associated risk factors on admission to a specialist care eye hospital. Ann Saudi Med 2002;22:153–7.
24. Alghaithy AA, Bilal NE, Gedebou M, Weily AH. Nasal carriageand antibiotic resistance of Staphylococcus aureusisolates from hospital and non-hospital personnel in Abha, Saudi Arabia. Trans R Soc Trop Med Hyg 2000; 94:504–7.
25. Dimitrov T, Udo EE, Grover S. Point surveillance of Staphylococcus aureus carriage among medical staff in Infectious Diseases Hospital, Kuwait. Med Princ Pract 2003; 12:139–44.
26. Biber A, Abuelaish I, Rahav G, Raz M, Cohen L, Valinsky L, et al. A typical hospital-acquired methicillin-resistant Staphylococcus aureus clone is widespread in the community in the Gaza strip. PLoS One 2012; 7:428–64.
27. Halablab MA, Hijazi SM, Fawzi MA, Araj GF. Staphylococcus aureus nasal carriage rate and associated risk factors in individuals in the community. Epidemio Infect 2010; 138:702–6.
28. Adwan K, Jarrar N, Abu-Hijleh A, Adwan G, Awaad E, Salameh Y. Molecular analysis and susceptibility patterns of methicillin-resistant Staphylococcus aureus strains causingcommunity- and health care-associated infections inthe northern region of Palestine. AmJ Infect Control 2013; 41:195–8.
29. Habeeb A, Hussein N, Assafi, M, Al-Dabbagh S. Methicillin resistant Staphylococcus aureus nasal colonization among secondary school students at Duhok City-Iraq". J Microbiol Infect Dis 2015; 4(02):59–63.
30. Hussein NR, Basharat Z, Muhammed AH, Al-Dabbagh SA. Comparative evaluation of MRSA nasal colonization epidemiology in the urban and rural secondary school community of Kurdistan, Iraq. PLoS ONE 2015; 10(5):e0124920.
31. Abed SY, AL-Marjani MF, Esa KR, Mansour RF. Prevalence of nasal carriage of methicillin-resistant Staphylococcus spp. in Baghdad. EJBPS 2016; 3(5):106–9.
32. Al-Dahbi AM, Al-Mathkhury HJ. Distribution of methicillin resistant Staphylococcus aureus in Iraqi patients and healthcare worker. Iraqi J Sci 2013; 54(2):293–300.
33. Warnke P, Harnack T, Ottl P, Kundt G, Podbielski A. Nasal screening for Staphylococcus aureus– Daily routine with improvement potentials. PLoS ONE 2014; 9(2):e89667.
34. Kloos WE, Bannerman TL. Staphylococcus and Micrococcus. In: Murray PR, Baron EJ, P faller MA, Tenover FC, Yolken RH, editors. Manual of clinical microbiology. 7th ed. Washington: ASM Press; 1991.
35. Clinical and Laboratory Standards Institute

(CLSI). Performance standards for antimicrobial susceptibility Testing; Twenty-fourth informational supplement. Vol. 34 (1). CLSI document M100-S21. Wayne: Clinical and Laboratory Standards Institute; 2014.
36. Basak S, Mallick SK, Bose S. Community associated Methicillin-resistant Staphylococcus aureus (CA-MRSA) an emerging pathogen: are we aware? J Clin Diagn Res 2010; 4:2111–5.
37. Wertheim HF, Vos MC, Ott A. Risk and outcome of nosocomial Staphylococcus aureus bacteraemia in nasal carriers versus non-carriers. Lancet 2004; 364:703–5.
38. Hernandez DR, Newton DW, Ledeboer NA, Buchan B, Young C, Clark AE, Connoly J, Wolk DM. Multicenter evaluation of MRSA Select II chromogenic agar for identification of methicillin -resistant Staphylococcus aureus from wound and nasal specimens. J Clin Microbiol 2016; 54:305–11.
39. Hussein NR, Assafi MS, Ijaz T. Methicillin-resistant Staphylococcus aureus nasal colonisation amongst healthcare workers in Kurdistan Region, Iraq. Journal of Global Antimicrobial Resistance 2017; 9:78–81.
40. Mohammed SH, Hmood MN, Abd AA, Obaid SA, Fahad BA, Kadhem FH. Screening of nasal carriage for Staphylococcus aureus and their resistance to oxacillin and cefoxitin among medical students in Karbala University. J Contemp Med Sci 2015; 1(1):13–6.
41. Askarian M, Zeinalzadeh A, Japoni A, Alborzi A, Memish ZA. Prevalence of nasal carriage of Methicillin-resistant Staphylococcus aureus and its antibiotic susceptibility pattern in healthcare workers at Namazi Hospital, Shiraz, Iran. Int J Infect Dis 2009; 13 (5):241–7.
42. Rahbar M, Karamiyar M, Gra-Agaji R. Nasal carriage of methicillin-resistant Staphylococcus aureus among healthcare workers of an Iranian hospital. Infect Control Hosp Epidemiol 2003; 24 (4):236–7.
43. Saderi H, Oulia P, Jalali Nadushan MR, Falah N, Barati Namin M. The rate of Staphylococcus aureus nasal carriage among personnel of a hospital in Tehran. Daneshvar Medicine 2004; 11 (49):33–8.
44. Aqel AA, Alzoubi HM, Vickers A, Pichon B, Kearns AM. Molecular epidemiology of nasal isolates of methicillin-resistant Staphylococcus aureus from Jordan. J Infect Public Health 2015;8:90–7.
45. Dulon M, Peters C, Schablon A, Nienhaus A. MRSA carriage among healthcare workers in non -outbreak settings in Europa and the United States: A systemicreview. BMC Infect Dis 2014; 14:363.
46. Naz H, Cevik F C, Aykin N. Nasal Staphylococcus aureus Carriage Among Hospital Staff in Eskişehir Yunus Emre State Hospital. Ankem 2006;20(3):141–4.
47. Arttan OM, Gulgun M, Baykan Z, Tok D. Investigation of nasal carriage rates and antimicrobial susceptibility of Staphylococcus aureus in hospital staff. Turkish J Infection 2008; 22 (2):87–90.
48. Yagmur G, Inci M. Investigation of nasal carriage and antibiotic susceptibility of Staphylococcus aureus in healthcare staff. J Harran Univ Med Fak 2015; 12:1.
49. 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;17:28.
50. Blok H, Troelstra A, Kamp-Hopmans, T, Gigengack-Baars A, Vandenbroucke-Grauls C, Weersink A. Role of healthcare workers in outbreaks of methicillin-resistant Staphylococcus aureus: A 10-year evaluation from a Dutch university hospital. Infect Control Hosp Epidemiol 2003; 24(9):679–85.
51. Kuehnert MJ, Kruszon-Moran D, Hill HA, McQuillan G, McAllister SK, Fosheim G. Prevalence of Staphylococcus aureus nasal colonization in the United States, 2001–2002. J Infect Dis 2006; 93:172–9.
52. Bouchillon SK, Johnson BM, Hoban DJ, Johnson JL, Dowzicky MJ, Wu DH, Visalli MA, Bradford PA. Determining incidence of extended spectrum β-lactamase producing Enterobacteriaceae, vancomycin-resistant Enterococcus faecium and methicillin-resistant Staphylococcus aureus in 38 centres from 17 countries: the PEARLS study 2001–2002. Int J Antimicrob Agents 2004; 24:119–24.
53. Barber M, Rozwadowska-Dowzenko M. Infection by penicillin-resistant staphylococci. Lancet 1948; 1:641–4.
54. Zinn CS, Westh H, Rosdahl VT. An international multicenter study of antimicrobial resistance and typing of hospital Staphylococcus aureus isolates from 21 laboratories in 19 countries or states. Microb Drug Resist 2004; 10:160–8.
55. Diekema DJ, Pfaller MA, Schmitz FJ, Smayevsky J, Bell J, Jones RN, et al. 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 2001; 32(2):5114–32.