International Journal of Infectious Diseases (2009) 13, e241—e247

http://intl.elsevierhealth.com/journals/ijid

Prevalence of nasal carriage of methicillin-resistant *Staphylococcus aureus* and its antibiotic susceptibility pattern in healthcare workers at Namazi Hospital, Shiraz, Iran

Mehrdad Askarian [a,*], Alihosein Zeinalzadeh [a], Aziz Japoni [b], Abdolvahab Alborzi [c], Ziad A. Memish [d]

[a] *Department of Community Medicine, Shiraz University of Medical Sciences, PO Box 71345-1737, Shiraz, Iran*
[b] *Molecular Bacteriology, Professor Alborzi Clinical Microbiology Research Center, Shiraz University of Medical Sciences, Shiraz, Iran*
[c] *Department of Pediatrics, Shiraz University of Medical Sciences, Shiraz, Iran*
[d] *Department of Medicine and Infection Prevention & Control Program, King Abdulaziz Medical City, King Fahad National Guard Hospital, Riyadh, Saudi Arabia*

Received 15 February 2008; received in revised form 28 October 2008; accepted 17 November 2008

KEYWORDS
Staphylococcus aureus;
MRSA;
Nasal carriage;
Antibiotic susceptibility;
Healthcare workers;
Iran

Summary
Objective: The aim of this study was to determine the prevalence of nasal carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) among healthcare workers (HCWs) at Namazi Hospital, Shiraz, Iran.
Methods: This cross-sectional study was conducted from July to November 2006. Nasal swabs were taken from 600 randomly selected HCWs. The isolates were identified as *S. aureus* based on morphology, Gram stain, catalase test, coagulase test, and mannitol salt agar fermentation. To analyze sensitivity patterns of MRSA strains more precisely, minimum inhibitory concentrations (MICs) of antibiotics were determined by the E-test method. All methicillin-resistant isolates were examined for the existence of the *mecA* gene by total DNA extraction and PCR.
Results: The prevalence of nasal carriage of methicillin-sensitive *S. aureus* (MSSA) was 25.7% and of MRSA was 5.3%, with the highest nasal carriage of MRSA in surgical wards and the emergency department. There was no significant difference between the sexes ($p = 0.247$), age ($p = 0.817$), and years of healthcare service ($p = 0.15$) with regard to the nasal carriage of MRSA and MSSA. In the univariate analysis, a statistically significant difference was only found for occupation ($p = 0.032$) between the carriage of MSSA and MRSA. In the multivariate analysis, the occupation 'nurse' was independently associated with MRSA carriage ($p = 0.012$, odds ratio 3.6, 95% confidence interval 1.3—9.7). The highest resistance rate for both gentamicin and clindamycin (69%) was noted among the MRSA strains. None of the MRSA strains were resistant to mupirocin,

* Corresponding author. Tel.: +98 917 1125777; fax: +98 711 2354431.
E-mail address: askariam@sums.ac.ir (M. Askarian).

doi:10.1016/j.ijid.2008.11.026

linezolid, fusidic acid, or vancomycin. The existence of the *mecA* gene in all 32 methicillin-resistant isolates was observed by PCR.
Conclusions: This study revealed the prevalence of nasal carriage of *S. aureus* strains among HCWs to be lower than that found in other studies from Iran. The antibiotic susceptibility patterns also differed, perhaps as a result of the excessive use of antibiotics at our hospital. Only the occupation of nurse was an independent risk factor for MRSA carriage.

Introduction

Staphylococcus aureus has been recognized as an epidemiologically important pathogen. Despite antibiotic therapy, staphylococcal infections occur frequently in hospitalized patients and have severe consequences.[1] Following the introduction of penicillin in the 1940 s, strains of *S. aureus* unaffected by penicillin were reported in 1945.[2,3] Methicillin was introduced in 1959 to treat these infections, but in 1961, shortly after the introduction of methicillin, *S. aureus* isolates that had acquired resistance to methicillin (methicillin-resistant *S. aureus*, MRSA) were reported.[4] The bacterial cell wall contains penicillin-binding proteins (PBPs), which have an enzymatic role in the synthesis of peptidoglycan. Normally, PBPs have a high affinity for beta-lactam antibiotics; in MRSA this affinity is reduced resulting in antibiotic resistance. In MRSA, a low-antibiotic affinity PBP known as PBP2a is encoded by the *mecA* gene.[2,3,5–7]

Several studies worldwide have reported the rate of nasal carriage of *S. aureus* strains varying from 16.8% to 90%.[1,8–10] In Iran the prevalence of nasal carriage of *S. aureus* among hospital personnel has varied between 28.2% and 44.5% in different studies.[11–18] In studies conducted by Goyal et al.[9] and Alghaithy et al.,[10] 6.6% and 18.3% were MRSA carriers, respectively. We have recently reported rates of 42.4% for MRSA and 23.5% for MSSA in our hospital patients infected with *S. aureus*.[19]

MRSA is a major nosocomial pathogen that causes severe morbidity and mortality worldwide.[20] Initially, MRSA was limited to hospitals, however it is now increasingly recovered from nursing homes and the community.[21] The emergence of MRSA, which is also often multidrug-resistant, renders the treatment of staphylococcal infections more challenging.[22] The aim of this study was to determine the prevalence of nasal carriage of MRSA among HCWs at Namazi Hospital, Shiraz, Iran, and to determine the susceptibility of the recovered isolates to various antibiotics.

Methods

Setting and design

The study hospital (Namazi Hospital) is a 750-bed, tertiary-care, teaching hospital with approximately 38 000 admissions per year, which serves about one fourth of the Iranian population. This cross-sectional study was carried out from July to November 2006 among HCWs from intensive care units, neurosurgery, general, pediatric, cardiovascular surgery, operating room, hemodialysis, internal medicine, pediatrics, laundry, and kitchen.

Subjects

Half of all staff members (600/1200) from all wards were asked to undergo screening for nasal carriage of *S. aureus* strains. They were randomly selected from the list of HCWs at this hospital. Doctors and medical students were excluded from the study. All personnel included in the study were full-time workers at Namazi Hospital. Personnel who worked part time at our hospital were excluded from the study.

Data collection

Data collected included: sex, age, ward, years of healthcare service, level of education (university graduate, high school graduate, or secondary school), occupation (nurse, auxiliary nurse, or non-medical personnel), history of hospitalization or antibiotic therapy during last three months, smoking habits, nasal abnormalities (sinusitis, allergic rhinitis, nasal septal deviation), and history of underlying diseases such as hypertension, ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), and diabetes mellitus (DM).

Microbiological methods

Specimens were taken from the subjects in the following way: a sterile moistened swab was inserted into each nostril in turn, to a depth of approximately 1 cm, and rotated five times.[23] For each specimen, both nostrils were sampled using the same swab. Trypticase soy broth (TSB) was used as the transport medium. The samples were quickly sent to the laboratory and were inoculated onto mannitol salt agar plates and incubated at 35 °C for 48 h. The isolates were identified as *S. aureus* based on morphology, Gram stain, catalase test, coagulase test, and mannitol salt agar fermentation. Methicillin-susceptible *S. aureus* strains (MSSA) were differentiated from MRSA using agar screen plates (Mueller–Hinton agar) containing 2 μg/ml oxacillin with 4% NaCl. Isolates with growths on the plates with 2 μg/ml of oxacillin were considered as a MRSA, while isolates that did not grow in the antibiotic-containing medium were considered as MSSA.

Antibiotic susceptibility determination

The sensitivity patterns of MSSA and MRSA strains were determined by disk diffusion method (Kirby–Bauer). The panel of antibiotics used in sensitivity tests included: oxacillin, vancomycin, mupirocin, gentamicin, linezolid, clindamycin, ciprofloxacin, rifampin, tetracycline, and fusidic acid. American type culture collection (ATCC) 29213 *S. aureus* was used as the control strain in antibacterial susceptibility determination. To analyze sensitivity patterns of MRSA

strains more precisely, minimum inhibitory concentrations (MICs) of methicillin (oxacillin) were determined by the E-test method (AB Biodisk, Sweden). The isolates were incubated overnight, following which the sensitivity breakpoints for MICs were determined. The sensitivity breakpoints for MICs and the antibiotic disk diffusion method were interpreted according to the manufacturer's instructions (AB Biodisk, Sweden) and the BSAC (British Society for Antimicrobial Chemotherapy) guidelines, respectively.[24]

Detection of *mecA* gene by PCR

All methicillin-resistant isolates were examined for the existence of the *mecA* gene by total DNA extraction and PCR. Briefly, the isolates were swabbed on trypticase soy agar (TSA) and the surface of the agar medium was covered with standard vancomycin disks, followed by incubation overnight. The vancomycin disk was used to weaken the thick cell wall of *S. aureus*. The weakened bacterial cell wall was then rapidly lysed simply by heating.[25] The bacterial colonies from the edges of the inhibition zone were then resuspended in sterile distilled water and matched to 0.5 McFarland standards (approximately 10^8 cfu/ml). The bacterial suspension was heated at 95 °C for 15 min and cooled at room temperature. The crude lysate (2.5 μl) was used as a DNA template for all isolates when PCR tests were carried out. To detect methicillin-resistant genes, the 147-bp band from *mecA* genes was amplified using two specific primers.[26]

Statistical analysis

Data were analyzed using SPSS 11.5 software. Qualitative variables were compared using the Chi-square or Fisher's exact test and quantitative variables were compared by one-way ANOVA. All *p*-values were two-sided with $p < 0.05$ being considered significant. A logistic regression model was built to identify risk factors. Variables with $p < 0.25$ were retained in the final model.

Ethical considerations

Informed oral consent was obtained from all study staff prior to specimen collection. The study was approved by the Ethics Committee of Shiraz University of Medical Sciences. Ethical considerations including privacy of personal data were considered during all steps of the research.

Results

During the study period, half of all HCWs at the studied hospital (600/1220) were screened for *S. aureus* carriage. The mean age of participants was 32.36 ± 8.3 years (range 19–74 years) with a male-to-female ratio of 0.47. Nasal screening identified 186 (31%) *S. aureus* carriers. Of the 186 nasal carriers of *S. aureus*, 154 (82.8%) carried MSSA and 32 (17.2%) carried MRSA (25.7% and 5.3% of all HCWs, respectively).

The frequency of MRSA and MSSA carriage also varied according to the ward (Table 1). The highest prevalence of nasal carriage of MRSA was in the surgical wards. The staff of the general, pediatric, cardiovascular and orthopedic surgery wards together with the emergency department accounted for 43.8% of all MRSA carriers. This study showed the highest rate of nasal carriage of MSSA (53.3%) in laundry and kitchen workers without any carriage of MRSA. In univariate analysis we divided the hospital departments into: emergency, internal medicine, pediatrics, intensive care units (ICUs), surgery and operating room, and non-medical (laboratory, laundry, kitchen, and paramedical staff) units and found no significant difference between MSSA and MRSA carriers ($p = 0.224$).

Table 1 Prevalence of nasal carriage of methicillin-sensitive and methicillin-resistant *Staphylococcus aureus* among healthcare workers at Namazi Hospital by ward ($N = 600$)

Ward	Nasal carriers		Total [a]
	MSSA, *n* (%)	MRSA, *n* (%)	
Pediatric	5 (15.2)	0 (0)	33
Emergency department	28 (26.9)	7 (6.7)	104
Internal medicine	10 (18.5)	3 (5.6)	54
Intensive care unit	9 (16.4)	5 (9.1)	55
Urology	1 (25)	0 (0)	4
Orthopedic	4 (28.6)	4 (28.6)	14
Heart surgery	3 (16.7)	1 (5.6)	18
General surgery	1 (9.1)	1 (9.1)	11
Pediatric surgery	1 (7.7)	1 (7.7)	13
Trauma	0 (0)	0 (0)	8
Plastic surgery	0 (0)	0 (0)	5
Neurosurgery	2 (11.8)	0 (0)	17
Transplantation	7 (50)	0 (0)	14
Operating room	24 (33.8)	4 (5.6)	71
Pediatric hematology	1 (100)	0 (0)	1
Laboratory	6 (22.2)	0 (0)	27
Laundry and kitchen	8 (53.3)	0 (0)	15
Janitors	29 (33.3)	3 (3.4)	87
Office personnel	15 (30.6)	3 (6.1)	49

MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*.
[a] The total consists of three groups: nasal carriers (MRSA and MSSA) and non-carriers.

Table 2 shows the results of univariate and logistic regression analysis of potential risk factors for nasal carriage of MSSA and MRSA. There was no significant difference between the sexes ($p = 0.247$), age ($p = 0.817$), and years of healthcare service ($p = 0.15$) between those with nasal carriage of MRSA and MSSA.

The other variables studied were level of education (university graduate, high school graduate, and secondary school) and occupation (nurse, auxiliary nurse, and non-medical personnel) of HCWs. There was a significant difference between nasal carriage of MRSA and MSSA ($p = 0.032$) with regard to occupation. However, there was no association between level of education and nasal carriers ($p = 0.23$).

We also studied the probable risk factors related to nasal carriage of MSSA and MRSA, such as previous hospitalization, antibiotic therapy during the last three months, smoking habits, nasal abnormalities, and underlying diseases (hypertension, IHD, COPD, and DM). There was no association between these and nasal carriage.

In the multivariate analysis, the only significant independent risk factor for nasal carriage of MRSA versus MSSA was

Table 2 Univariate and multivariate analysis of potential factors for nasal carriage of methicillin-sensitive and methicillin-resistant *Staphylococcus aureus* among healthcare workers at Namazi Hospital

Variable	Carrier status		*p*-Value	Logistic regression	
	MSSA, *n* (%)	MRSA, *n* (%)		OR[a] (95% CI)	*p*-Value
Gender			0.247		0.779
Male	66 (42.9)	11 (34.4)			
Female	88 (57.1)	21 (65.6)			
Age (years), mean ± SD	33.16 ± 9.3	33.56 ± 7.2	0.817		
Stratified age (years)			0.21		
<30	73 (47.4)	12 (37.5)			
30–50	74 (48.1)	20 (62.5)			
>50	7 (4.5)	0			
Years of working, mean ± SD	8.85 ± 7.4	10.98 ± 8.2	0.15		
Stratified years of working			0.248		
0–9	102 (66.2)	17 (53.1)			
10–19	36 (23.4)	12 (37.5)			
20–36	16 (10.4)	3 (9.4)			
Ward			0.224		0.788
Internal medicine and pediatrics	46 (29.9)	7 (21.9)			
Emergency	28 (18.2)	7 (21.9)			
ICU	9 (5.8)	5 (15.6)			
Surgery and operating room	42 (27.3)	10 (31.2)			
Non-medical	29 (18.8)	3 (9.4)			
Level of education			0.23		0.626
University graduate	78 (50.6)	21 (65.6)			
High school graduate	38 (24.7)	7 (21.9)			
Secondary school	38 (24.7)	4 (12.5)			
Occupation			0.032		
Nurse	52 (33.8)	17 (53.1)		3.6 (1.3–9.7)	0.012
Auxiliary nurse	36 (23.4)	9 (28.1)		1.3 (0.53–3.3)	
Previous hospitalization			0.725		
Absent	149 (96.8)	31 (96.9)			
Present	5 (3.2)	1 (3.1)			
Antibiotic use in previous 3 months			0.16		
Absent	117 (76.0)	21 (65.6)			
Present	37 (24.0)	11 (34.4)			
Smoking habits			0.244		
Absent	143 (92.9)	28 (87.5)			
Present	11 (7.1)	4 (12.5)			
Nasal abnormalities			0.593		
Absent	120 (77.9)	25 (78.1)			
Present	34 (22.1)	7 (21.9)			
Underlying disease					
HTN/IHD			0.81		
Absent	153 (99.4)	32 (100)			
Present	1 (0.6)	0			
COPD			0.79		
Absent	152 (99)	32 (100)			
Present	2 (1)	0			
DM			0.02		
Absent	150 (98.7)	32 (100)			
Present	4 (2.6)	0			

MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio; CI, confidence interval; ICU, intensive care unit; HTN, hypertension; IHD, ischemic heart disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.
[a] OR is comparing the odds of having MSSA to the odds of having MRSA.

Table 3 Antibiotic susceptibility of *Staphylococcus aureus* isolates (MSSA and MRSA) from Namazi Hospital personnel by Kirby–Bauer method

Antibiotic	MSSA (*N* = 154), *n* (%)			MRSA (*N* = 32), *n* (%)		
	S	I	R	S	I	R
Oxacillin	154 (100)	0	0	0	0	32 (100)
Mupirocin	154 (100)	0	0	32 (100)	0	0
Linezolid	154 (100)	0	0	32 (100)	0	0
Fusidic acid	154 (100)	0	0	32 (100)	0	0
Vancomycin	154 (100)	0	0	31 (97)	1 (3)	0
Rifampin	154 (100)	0	0	31 (97)	0	1 (3)
Tetracycline	96 (62)	28 (18)	30 (20)	18 (56)	1 (3)	13 (41)
Clindamycin	102 (66)	52 (34)	0	10 (31)	0	22 (69)
Ciprofloxacin	100 (65)	52 (34)	2 (1)	9 (28)	2 (6)	21 (66)
Gentamicin	57 (37)	13 (8)	84 (55)	7 (22)	3 (9)	22 (69)

MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; S, sensitive; R, resistant; I, intermediate.

the occupation 'nurse' (odds ratio 3.6, 95% confidence interval 1.3–9.7; $p = 0.012$).

The sensitivity of *S. aureus* isolates (MSSA and MRSA) to the tested antibiotics is shown in Table 3. In addition, the MICs for oxacillin are listed in Table 4. Overall, 154 (25.7%) isolates were methicillin-sensitive (MSSA) and 32 (5.3%) were methicillin-resistant (MRSA). The highest resistance rate for both gentamicin and clindamycin (69%) was noted among the MRSA strains, while the highest resistance in MSSA strains was to gentamicin (55%). None of the MRSA strains (0%) were resistant to mupirocin, linezolid, fusidic acid, or vancomycin. Seven MRSA isolates had intermediate (borderline) resistance as follows: one (3%) to vancomycin, three (9%) to gentamicin, two (6%) to ciprofloxacin, and one (3%) to tetracycline. All MSSA strains were sensitive to mupirocin, linezolid, fusidic acid, rifampin, and vancomycin. The existence of the *mecA* gene in all 32 methicillin-resistant isolates was observed by PCR (Figure 1).

Discussion

The prevalence of nasal carriage of MRSA among HCWs at our hospital has not been determined to date. This study revealed that 31% of HCWs were carriers of *S. aureus* strains. Of these, 17.2% were MRSA (i.e., 5.3% of all HCWs). However, the carriage rate of *S. aureus* and MRSA in the present study cannot be generalized. The estimated prevalence in our study was significantly lower than that found in the studies of Rahbar et al.,[11] Mosavi,[12] Ghasemian et al.,[13] Khoddami,[14] Mansuri and Khaleghi,[15] and Rashidian et al.[16] Differences in the prevalence of nasal carriage of *S. aureus* strains may be due in part to differences in the quality and size of samples and the use of different techniques and different interpretation guidelines.

The frequency of MRSA and MSSA carriage also varies between hospital wards. In the present study, 43.8% of the MRSA carriers were working in several surgical units and the emergency department. An important finding of this study is that the highest prevalence of nasal carriage of MSSA (53.3%) was found in laundry and kitchen workers without any carriage of MRSA. A reason for this may be the lack of direct contact between these personnel and patients. This finding confirms the effect of close contact on the transmission of bacteria from patients to personnel.

The only occupation found to have an association with carrier status was having a nursing job, which increased the

Table 4 Frequency and range of methicillin (oxacillin) MICs for 32 isolates of MRSA from Namazi Hospital personnel by E-test

MIC (μg/ml)	Number
8	1
12	1
16	2
24	1
32	5
64	13
128	7
256	2

MIC, minimum inhibitory concentration; MRSA, methicillin-resistant *Staphylococcus aureus*.

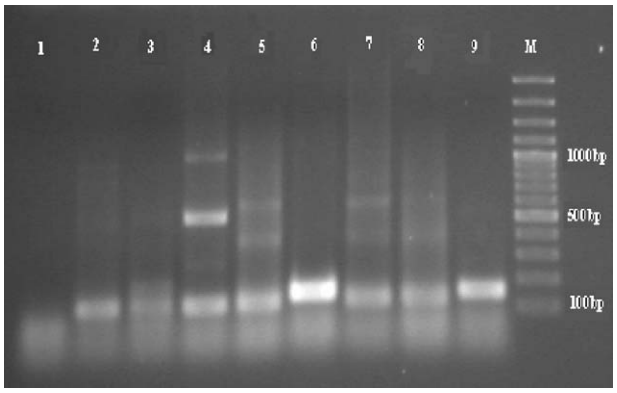

Figure 1 Detection of the *mecA* gene by PCR. Lane 1, negative control MSSA strain ATCC 29213; lanes 2–9, eight representative MRSA strains isolated from personnel (amplicon size 147 bp); M, 100-bp marker.

risk of nasal carriage of MRSA 3.6-fold. We found that the other variables studied were not risk factors for nasal carriage of *S. aureus* strains. We noticed high rates of MRSA among patients who were infected with *S. aureus* at our hospital. This may indicate cross-contamination of MRSA between personnel and patients. However, further molecular epidemiology studies such as DNA sequencing and pulsed field gel electrophoresis are needed to clarify the existence of any circulating clones.

To our knowledge, the present study is the first from Iran to evaluate the susceptibility of *S. aureus* strains from HCWs to linezolid and fusidic acid. All the *S. aureus* isolates recovered from nasal carriers, both MRSA and MSSA, were susceptible to linezolid, fusidic acid, rifampin and mupirocin, possibly because the use of these antibiotics in Iran is limited. In view of the high resistance rates of MRSA to gentamicin, clindamycin, tetracycline, and ciprofloxacin, empirical treatment of MRSA infections at our hospital with these antibiotics may not be effective. The full susceptibility of *S. aureus* to linezolid, fusidic acid, rifampin, and mupirocin observed in this study indicates that these antibacterial agents are effective for the treatment of *S. aureus* infections at our hospital. To date, mupirocin has not been used for the eradication of *S. aureus* in nasal carriers at our hospital. Local therapy with mupirocin ointment has been shown to eliminate MRSA nasal colonization in both patients and hospital personnel.[27–29]

There was a relationship between methicillin resistance and resistance to other antibiotics, as noted in previous investigations.[30–33] Thus, this is a major problem in the treatment of *S. aureus* infections. Our study also supports the observation of a relationship between oxacillin and aminoglycoside resistance in *S. aureus*. More than 69% of MRSA were resistant to gentamicin, while the frequency of MRSA resistance to the tetracyclines was 41%. In the last few years, understanding of the genetic basis for methicillin resistance has advanced significantly. So far, staphylococcal cassette chromosome mec (*SCCmec*) elements are the only vectors that have been described for the *mecA* gene encoding resistance in staphylococci.[34] PCR testing confirmed that all MRSA strains isolated from our HCWs were *mecA* gene-positive. This study was preliminary and the initiation of further molecular studies is required to track *mecA* in our isolates.

As shown by Shitrit et al.,[35] contact isolation precautions can prevent new colonization and infection and lead to a significant reduction in morbidity and healthcare costs. However, active surveillance culture is important for identifying hidden reservoirs of MRSA. Currently there is no such active surveillance and policy for MRSA at our hospital. Previous studies at our university hospitals have shown that compliance with contact isolation precautions is not well accepted among nurses,[36] medical students,[37] and physicians.[38]

In conclusion, this study revealed that the prevalence of nasal carriage of *S. aureus* strains among HCWs was lower than that found in other studies in our country. Univariate analysis suggests that only occupation is a risk factor for nasal carriage of MRSA among HCWs. Logistic regression showed that having a nursing occupation is independently associated with MRSA carriage. Antibiotic susceptibility patterns were different to those of the other studies, which could be as a result of the excessive use of antibiotics at our hospital. All *S. aureus* isolates that we recovered from nasal carriage were susceptible to mupirocin. Hence, topical mupirocin could be used to eradicate nasal staphylococcal colonization and carriage.

Acknowledgements

Our study was funded by the Deputy of Research at the Shiraz University of Medical Sciences and Professor Alborzi Clinical Microbiology Research Center.

Ethical approval: The Ethics Committee of Shiraz University of Medical Sciences approved this study.

Conflict of interest: No conflict of interest to declare.

References

1. Kluytmans J, van Belkum A, Verbrugh H. Nasal carriage of *Staphylococcus aureus*: epidemiology, underlying mechanism and associated risks. *Clin Microbiol Rev* 1997;**10**:505–20.
2. Shehabel-Din SA, El-Shafey E, El-Hadidy M, Bahaa El-Din A, El-Hadidy M, Zaghloul H. Methicillin-resistant *Staphylococcus aureus*: a problem in the burns unit. *Egypt J Plast Reconstr Surg* 2003;**27**:1–10.
3. Korn GP, Martino MD, Mimica IM, Mimica LJ, Chiavone PA, Musolino LR. High frequency of colonization and absence of identifiable risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) in intensive care units in Brazil. *Braz J Infect Dis* 2001;**5**:1–7.
4. Enright MC, Robinson DA, Randle G, Feil EJ, Grundmann H, Spratt BG. The evolutionary history of methicillin-resistant *Staphylococcus aureus* (MRSA). *Proc Natl Acad Sci USA* 2002;**99**:7687–92.
5. Silvana M, Emmanuel R, Carlos C. Prevalence of *Staphylococcus aureus* introduced into intensive care units of a university hospital. *Braz J Infect Dis* 2005;**9**:1–12.
6. Hardy KJ, Hawkey PM, Gao F, Oppenheim BA. Methicillin-resistant *Staphylococcus aureus* in the critically ill. *Br J Anaesth* 2004;**92**:121–30.
7. Johnson A, Pearson A, Duckworth G. Surveillance and epidemiology of MRSA bacteraemia in the UK. *J Antimicrob Chemother* 2005;**56**:455–62.
8. Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchmann SD. Guideline for infection control in health care personnel, 1998. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1998;**19**:407–63.
9. Goyal R, Das S, Mathur M. Colonisation of methicillin-resistant *Staphylococcus aureus* among health care workers in a tertiary care hospital of Delhi. *Indian J Med Sci* 2002;**56**:321–4.
10. Alghaithy AA, Bilal NE, Gedebou M, Weily AH. Nasal carriage and antibiotic resistance of *Staphylococcus aureus* isolates from hospital and non-hospital personnel in Abha, Saudi Arabia. *Trans R Soc Trop Med Hyg* 2000;**94**:504–7.
11. Rahbar M, Karamiyar M, Gra-Agaji R. Nasal carriage of methicillin-resistant *Staphylococcus aureus* among healthcare worker of an Iranian hospital. *Infect Control Hosp Epidemiol* 2003;**24**:236–7.
12. Mosavi M. Positive Staphylococcus-coagulase carriers in Qazvin Hospital staff. *J Qazvin Univ Med Sci Health Serv* 1996;**1**:29–37.
13. Ghasemian R, Najafi N, Shojaifar A. Nasal carriage and antibiotic resistance of *Staphylococcus aureus* isolates of Razi Hospital personnel, Qaemshahr, 1382. *J Mazandaran Univ Med Sci* 2003;**44**:79–86.
14. Khoddami E. A survey on nasal carriers of *Staphylococcus aureus* among hospital staff. *J Babol Univ Med Sci* 2000;**10**:52–5.
15. Mansuri SH, Khaleghi M. Nose and throat carrier rate of *S. aureus* in the staff of four university hospitals in Kerman and comparison with the control and patients group. *J Tehran Fac Med* 1997;**1**:36–41.

16. Rashidian M, Taherpoor A, Goodarzi S. Nasal carrier rates and antibiotic resistance of *Staphylococcus aureus* isolates of Beasat Hospital staff. *Sci J Kurdistan Univ Med Sci* 2000;**21**:1—8.
17. Jazayeri Moghadas A. Frequency of nasal carriers of coagulase-positive staphylococci in medical personnel of teaching hospitals in Semnan. *Koomesh — J Semnan Univ Med Sci* 1999;**3**:49—55.
18. Hashemi S, Aghi H. Nasal carrier rate of *Staphylococcus aureus* in medical and non-medical staff and their antibiotic sensitivity. *Sci J Hamadan Univ Med Sci Health Serv* 1998;**5**:10—5.
19. Japoni A, Alborzi A, Orafa F, Rasouli. Farshad S. Distribution patterns of methicillin resistance genes (mecA) in Staphylococcus aureus isolated from clinical specimens. *Iranian Biomed J* 2004;**8**:173—8.
20. Haddadin AH, Fappiano SA, Lipset PA. Methicillin-resistant Staphylococcus aureus (MRSA) in the intensive care unit. *Postgrad Med J* 2002;**78**:385—92.
21. Mainous AG, Hueston WJ, Everett CJ, Diaz VA. Nasal carriage of *Staphylococcus aureus* and methicillin-resistant *S. aureus* in the United States, 2001—2002. *Ann Fam Med* 2006;**4**:132—7.
22. Choi CS, Yin CS, Bakar AA, Sakewi Z, Naing NN, Jamal F, et al. Nasal carriage of *Staphylococcus aureus* among healthy adults. *J Microbiol Immunol Infect* 2006;**39**:458—64.
23. Scarnato F, Mallaret MR, Croizé J. Incidence and prevalence of methicillin-resistant *Staphylococcus aureus* nasal carriage among healthcare workers in geriatric departments: relevance to preventive measures. *Infect Control Hosp Epidemiol* 2003;**24**: 456—8.
24. MacGowan AP, Wise R. Establishing MIC breakpoints and the interpretation of in vitro susceptibility tests. *J Antimicrob Chemother* 2001;**48**:17—28.
25. Japoni A, Alborzi A, Rasouli M, Pourabbas B. Modified DNA extraction for rapid PCR detection of methicillin-resistant staphylococci. *Iranian Biomed J* 2004;**8**:161—5.
26. Zhang K, McClure JA, Elsayed S, Louie T, Conly JM. Novel multiplex PCR assay for characterization and concomitant subtyping of staphylococcal cassette chromosome *mec* types I to V in methicillin-resistant *Staphylococcus aureus*. *J Clin Microbiol* 2005;**43**:5026—33.
27. Harbarth S, Dharan S, Liassine N, Herrault P, Auckenthaler R, Pittet A. Randomized, placebo-controlled, double-blind trial to evaluate the efficacy of mupirocin for eradicating carriage of methicillin-resistant *Staphylococcus aureus*. *Antimicrob Agents Chemother* 1999;**43**:1412—6.
28. Martin JN, Perdreau-Remington F, Kartalija M, Pasi OG, Webb M, Gerberding JL, et al. A randomized clinical trial of mupirocin in the eradication of *Staphylococcus aureus* nasal carriage in human immunodeficiency virus disease. *J Infect Dis* 1999;**180**: 896—9.
29. Coia JE, Duckworth GJ, Edwards DI, Farrington M, Fry C, Humphreys H, et al. Guidelines for the control and prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities. *J Hosp Infect* 2006;**63**(Suppl 1):S1—44.
30. Kim HB, Jang HC, Nam HJ, Lee YS, Kim BS, Park WB, et al. In vitro activities of 28 antimicrobial agents against *Staphylococcus aureus* isolates from tertiary-care hospitals in Korea: a nationwide survey. *Antimicrob Agents Chemother* 2004;**48**:1124—7.
31. 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.
32. 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**(Suppl 2):S114—32.
33. Fluit AC, Wielders CL, Verhoef J, Schmitz FJ. Epidemiology and susceptibility of 3051 *Staphylococcus aureus* isolates from 25 university hospitals participating in the European SENTRY study. *J Clin Microbiol* 2001;**39**:3727—32.
34. Hanssen AM, Ericson Sollid JU. *SCCmec* in staphylococci: genes on the move. *FEMS Immunol Med Microbiol* 2006;**46**:8—20.
35. Shitrit P, Gottesman BS, Katzir M, Kilman A, Ben-Nissan Y, Chowers M. Active surveillance for methicillin-resistant *Staphylococcus aureus* (MRSA) decreases the incidence of MRSA bacteremia. *Infect Control Hosp Epidemiol* 2006;**27**:1004—8.
36. Askarian M, Shiraly R, McLaws ML. Knowledge, attitudes, and practices of contact precautions among Iranian nurses. *Am J Infect Control* 2005;**33**:486—8.
37. Askarian M, Aramesh K, Palenik CJ. Knowledge, attitude, and practice toward contact isolation precautions among medical students in Shiraz, Iran. *Am J Infect Control* 2006;**34**:593—4.
38. Askarian M, Shiraly R, Aramesh K, McLaws ML. Knowledge, attitude, and practices regarding contact precautions among Iranian physicians. *Infect Control Hosp Epidemiol* 2006;**27**:868—72.