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Original Article

Staphylococcus Aureus Carriage among Healthcare Workers in Burn and Surgical Critical Care Units in Menoufia University Hospital, Egypt

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Abstract

Objectives: This study aimed to investigate *Staphylococcal aureus (S. aureus)* carriage among healthcare workers (HCWs) in Burn and Surgical Critical Care Units in Menoufia University Hospital, Egypt, following an outbreak of *S. aureus* wound infection in patients.

Methods: The study involved 60 HCWs. They were 9 Doctors (15.0%) and 51 nurses and workers (85.0%). Each participant completed a questionnaire that covered demographic data, smoking habits, risk factors of *S. aureus* colonization and general infection control procedures. To detect *S. aureus* colonization, both nasal and hand swabs were collected from HCWs. Testing for sensitivity to methicillin was performed by cefoxitin disc diffusion method (30µg).

Results: *S. aureus* was isolated from 53.3% of HCWs and 68.8% of them were colonized with MRSA strains. The overall *MRSA* carriage rate was 36.7%. MRSA was confined only in Surgical intensive care units (ICUs). *MRSA* isolates were sensitive to amikacin, chloramphenicol, vancomycin and ceftriaxone. There was no correlation between infection control training, antibiotic intake in the preceding month, duration of work, diabetes mellitus and smoking of HCWs and carriage rate of *MRSA* (P >0.5).

Conclusion: HCWs who had contact with patients were at risk of acquisition and colonization with S. aureus and antimicrobial resistant bacteria especially *MRSA*. Training of HCWs on hygienic measures especially proper hand hygiene is the key to overcome *S. aureus* infection in Surgical ICUs and Burn Units.

Key wards: *S. aureus, MRSA*, HCWs, Surgical ICU, Burn, Egypt

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INTRODUCTION

Staphylococcal aureus (S. aureus) is a type of bacteria that about 30% of people carry in their noses. Staphylococci multiply in the nose, on the skin, in the lesions and they can survive for sometime outside the body. It is one of the most common causes of nosocomial infections.(1) Some strains of Staphylococci developed resistance to penicillin by producing an enzyme (β-lactamase). A number of synthetic derivatives of penicillin resistant to β-lactamase enzyme were developed. One of these was methicillin which became the standard treatment for *S. aureus.* In 1961, the first methicillin resistant strains of *S. aureus* (*MRSA*) were isolated in Europe.(2) In many countries emergence of *MRSA* has led to major outbreaks in hospitals. The role of *MRSA* carriers in the transmission of this pathogen is critical. HCWs can cause outbreaks of *MRSA* infection if they are carriers. A carrier of *MRSA* is a person who is colonized by the organism in the nares (nose), sputum, urine, open wound, stools or skin without clinical manifestations of the disease.(3) Such carriers may transmit the organism to another person through direct contact, usually through colonized hands and aerosolization following sneezing. Therefore, healthcare givers who are at the interface between the hospital and the community may serve as agents for cross-transmission of *MRSA*.(4)

The spectrum of infections due to *MRSA* varies from mild skin infections to serious and invasive diseases such as septicemia, pneumonia, endocarditis, deep seated abscesses and toxinosis including food poisoning and toxic shock syndrome.(5) These lead to worse outcome in addition to prolonged hospital stay, higher cost of treatment and increased mortality.(6) Once a nosocomial infection has been recognized as

such, an outbreak investigation is usually initiated in order to discover its source. The source of the outbreak may get traced to a particular single HCW in some of the cases.[7] Although the precise route of infection is often unclear, the hands, the clothing, and the equipment of HCWs may play a role in facilitating patient-to-patient transmission.[8] Patients in ICU and burn units are at high risk of developing *MRSA* bacteremia. The problem is compounded in the Burn Units as patients are severely immunocompromised and receive numerous antibiotics.[9] Therefore, this study was initiated to know the rate of *S. aureus* carriage among HCWs at Surgical ICU and Burn Units of a tertiary care hospital.

The aim of the present study was to investigate the carriage of *S. aureus* among HCWs in Surgical ICU and Burn Units in Menoufia University Hospital, Egypt, following the detection of cases of *S. aureus* wound infection in patients.

METHODS

Setting and population: The study was a point prevalence survey of *S. aureus* carriage among HCWs during an outbreak of infections among patients in Surgical ICU and Burn Units at Menoufia University Hospital (a tertiary-care and teaching hospital), Egypt. The study was conducted during the period from May to August 2014. All HCWs in the Surgical ICU and Burn Units (60 HCWs) including 9 doctors and 51 nurses and workers who had access to the patients' rooms were included in the study.

Data collection: all study participants were subjected to filling an interviewing questionnaire that covered data about socio-demographic data, smoking habits, history of diabetes mellitus, previous and current antibiotic use, use of protective clothing, and general infection control procedures was administered and completed by all the participants under the supervision of an expert interviewer.

Screening for *S. aureus* colonization: Swabs were taken from the commonly recommended sites for screening for colonization, including nostrils, and hands (from web spaces and nails of hands). Two swabs from each subject were collected. A HCW was classified as a carrier if at least one of the two swabs taken tested positive for *S. aureus*.[10] The microbiological investigations were done at the infection control unit in Menoufia University Hospital applying the following procedures.

A-Culture: Samples were inoculated onto nutrient, blood, MacConkey and Mannitol Salt Agar (MSA) plates and incubated aerobically at $37^{O}C$ for 24-48 hours.

B-Identification of the isolates [11]: The resultant colonies were subjected to further morphological and biochemical identification to identify different bacterial species. Organisms other than *S. aureus* were identified and recorded. *S. aureus* was identified on the basis of culture characteristics, morphology and biochemical tests. *S. aureu*s colonies on nutrient agar were 1-3 mm in diameter, smooth, convex, glistening, densely opaque and creamy to gold in color. On blood agar, colonies were sometimes surrounded by narrow zone of haemolysis. On MSSA, *S. aureus* forms yellow colonies surrounded by yellow zone after incubation for 24-48 hours. *S. aureus* colonies were verified using Gram staining and the coagulase test; *S. aureu*s is Gram-positive spherical cocci arranged in clusters, and is distinguished from other Staphylococci by its production of coagulase and catalase enzymes

C- Detection of sensitivity of *S. aureus* isolates to methicillin by cefoxitin disc diffusion test: Direct colony suspension in saline was prepared and matched with the turbidity standard equivalent to 0.5 MacFarland standards. A plate of Mueller Hinton agar was inoculated and cefoxitin disc 30 µg was applied to the plate. The plate was incubated at 37ºc for 24 hours. The results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines for cefoxitin susceptibility testing: a zone size ≤ 19mm was considered resistant and ≥ 20mm was considered susceptible.[12]

D-Antibiotic Susceptibility Testing: The isolated Staphylococcus strains were tested for resistance to antimicrobial agents by performing disc diffusion method using commercial discs (bioMerieux) according to the guidelines of the national committee for (CLSI).(12). Tested antibiotics included penicillin (10 unit), ampicillin (10µg), oxacillin (30 µg), carbencillin, amoxicillin clavulanate 30 µg (20 µg amoxicillin +10 µgclavulanic acid), ceftriaxone (30 µg), vancomycin (30 µg), gentamycin, tobramycin (tob)10µg, tetracycline (30µg), chloramphnicol (30µg), cotrimoxazole) 25 µg, ciprofloxacin (5 µg), and rifampicin (5 µg), amikacin.

Statistical analysis: The results were collected, tabulated and statistically analyzed using SPSS statistical package, version 11. The data were presented as descriptive statistics and the chi-square test was done to study the association between qualitative variables. Fisher exact test was done when more than 25% of the cells contained an expected count less than 5. Z test was calculated for comparison of two proportions in the same group. P value of < 0.05 was considered statistically significant.

Ethical statement

The study procedure conformed to the international research guidelines, the ethical guidelines of the 1975 Declaration of Helsinki and Guidelines of the International Conference on Harmonization for Good Clinical Practice. Verbal consent was obtained from

all the study participants. Ethical approval to perform the study was obtained from the Ethics Committee in the Faculty of Medicine, Menoufia University and the management board of the hospital.

RESULTS

Table (1) shows that, the study included 60 HCWs; equally divided between surgical ICU and Burn Units. Fifteen percent were doctors and 85.0% were nurses and workers. Males constituted 23.3% while females were 76.7%. Their mean age was (35.6±9.9) years. About 46.6% of HCWs worked ≤ 5 years while 28.3% worked from 6-10 years and 25.1% worked more than 10 years in this occupation. *S. aureus* was found in 53.3% of studied HCWs, methicillin sensitive *S. aureus* (MSSA) constituted 18.3% and methicillin resistant *S. aureus* constituted 36.7%. In association with *S. aureus*, bacterial isolates included S. *epidermidis which was isolated* from 25.0% of HCWs, *Klebsiella pneumoniae* from 10.0%, E.coli from 11.7% and also lactose non fermenter (*Pseudomonas or Proteus*) from 11.7% of HCWs. On the other hand, 11 HCWs (18.3%) showed no colonization of any of the previous types of bacteria.

Table 1: Socio-demographic characteristics of HCWs in Burn and Surgical ICU units in Menoufia University Hospitals

Characteristics	Healthcare workers in burn and ICU units (n=60)	
	No	%
Department:		
• **Burn**	30	50.0
• **ICU**	30	50.0
Sex:		
• **Males**	14	23.3
• **Females**	46	76.7
Occupations:		
• **Doctors**	9	15.0
• **Nurses and workers**	51	85.0
Duration of work (years):		
• **≤ 5**	28	46.6
• **6-10**	17	28.3
• **> 10**	15	25.1
Age (years)		
X±SD	35.6 ±9.9	

MSSA was significantly the predominant type of *S. aureus* in Burn Unit than in Surgical ICU (33.3% versus 3.3%, P=0.003) while *MRSA* was found only in surgical ICU (73.3%). *S. epidermidis* was significantly isolated from Burn Unit than the Surgical ICU (36.7% versus 13.3%, P= 0.037) while lactose non fermenter bacteria was predominant in Surgical ICU. Otherwise, there was no significant difference between the two departments regarding other types of isolates as shown in table (2).

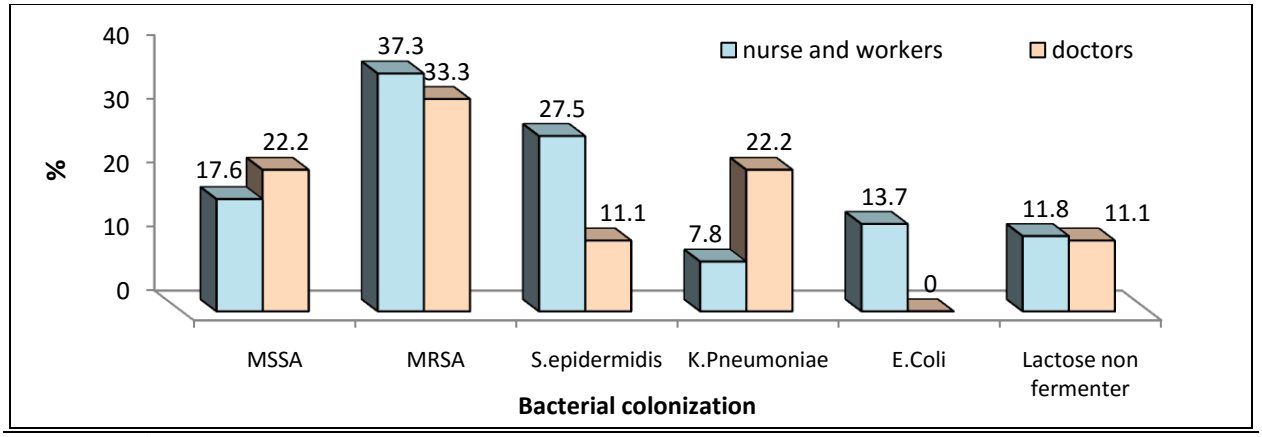
Table 2: Bacterial colonization in HCWs in Burn and Ssurgical ICU units in Menoufia University hospital

Bacterial colonization	Surgical ICU (n=30)		Burn (n=30)		Total (n=60)		χ^2	P value
	No	%	No	%	No	%		
S. aureus	22	73.3	10	33.3	32	53.3	9.64	0.002
MSSA	1	3.3	10	33.3	11	18.3	9.02	0.003
MRSA	22	73.3	0	0.0	22	36.7	34.74	0.000
S. epidermidis	4	13.3	11	36.7	15	25.0	4.36	0.037
klebsiella pneumoniae	2	6.7	4	13.3	6	10.0	0.741	0.389
E- coli	5	16.7	2	6.7	7	11.7	1.46	0.228
Lactose non fermenter	6	20.0	1	3.3	7	11.7	4.04	0.044
No colonization*	8	26.7	3	11	11	18.3	2.78	0.095

MSSA: Methicillin sensitive Staphylococcus aureus
MRSA: Methicillin resistant Staphylococcus aureus
* No colonization with the previous types of bacteria
NB: One case had both MSSA and MRSA stains

There is no significant association between bacterial colonization in the studied HCWs regarding their occupation (Fig: 1). Examination of antibiotic sensitivity profile of *MRSA* isolated from noses and hands of HCWs in surgical ICU revealed that the organism showed complete resistance (100.0%) to penicillin, cefoxitin and

oxacillin. There were higher resistance to tetracycline followed by ampicillin (77.3%), tobramycin and rifampicin (68.2%), amoxicillin (63.6%) trimethoprim (59.1%) and gentamycin (54.5%). On the other hand *MRSA* was mostly sensitive to amikacin (77.3%) followed by chloramphenicol (68.8%), ceftriaxon and vancomycin (63.6%) as shown in table (3).



* Z test was performed; P< 0.05

Figure 1: Bacterial colonization in HCWs in Burn and Surgical ICU units in Menoufia University hospitals by occupation

Table 3: Antibiotic sensitivity profile of MRSA isolates from HCWs in surgical ICU in Menoufia University hospitals

Antibiotics		Nose (n=13)		Hands (n=9)		Total (n=22)	
		No	%	No	%	No	(%)
Cefoxitin	R	13	100.0	9	100.0	22	100.0
	S	0	0.0	0	0.0	0	0.0
Oxacillin	R	13	100.0	9	100.0	22	100.0
	S	0	0.0	0	0.0	0	0.0
Amikacim	R	3	23.1	2	22.2	5	22.7
	S	10	76.9	7	77.8	17	77.3
Rifampicin	R	9	69.2	6	66.7	15	68.2
	S	4	30.8	3	33.3	7	31.8
Chloramphenicol	R	5	38.5	2	22.2	7	31.8
	S	8	61.5	7	77.8	15	68.8
Tetracyclin	R	12	92.3	6	66.7	18	81.8
	S	1	7.7	3	33.3	4	18.2
Trimethoprim	R	7	53.8	6	66.7	13	59.1
	S	6	46.2	3	33.3	9	40.9
Tobramycin	R	7	53.8	8	88.9	15	68.2
	S	6	46.2	1	11.1	7	31.8
Gentamycin	R	6	46.2	6	66.7	12	54.5
	S	7	53.8	3	33.3	10	45.5
Vancomycin	R	5	38.5	3	33.3	8	36.4
	S	8	61.5	6	66.7	14	63.6
Ceftriaxon	R	7	53.8	1	11.1	8	36.4
	S	6	46.2	8	88.9	14	63.6
Amoxicillin clavulinate	R	8	61.5	6	66.7	14	63.6
	S	5	38.5	3	33.3	8	36.4
Carbencillin	R	6	46.2	5	55.6	11	50.0
	S	7	53.8	4	44.4	11	50.0
Ampicillin	R	10	76.9	7	77.8	17	77.3
	S	3	23.1	2	22.2	5	22.7
Penicillin	R	13	100.0	9	100.0	22	100.0
	S	0	0.0	0	0.0	0.0	0.0

The analysis of the questionnaire revealed negligence of use of personal protective measures as only (36.6%) of the participating HCWs always wore gloves on handling patients. Twenty six percent of them changed gloves between patients. Wearing masks on exposure to patients was always applied only by 35.0%of HCWs. Only 26.7% of the participants always perform hand hygiene after contact with patients as shown in table (4).

Table 4: Staphylococcal colonization in HCWs in Burn and Surgical ICU units in Menoufia University hospitals by use of personal protective measures

Personal protective measures	Use of personal protective measures by HCWs (n=60)			
	Always No (%)	Usually No (%)	Sometimes No (%)	Never No (%)
Wearing of gloves				
colonized	5 (8.3)	7 (11.7)	12 (20.0)	8(13.3)
not colonized	17 (28.3)	8 (13.3)	1 (1.7)	2 (3.3)
Total	22 (36.6)	15 (25.0)	13 (21.7)	10(16.7)
Replacement of gloves between patients				
colonized	6 (10.0)	12 (20.0)	7 (11.7)	7 (11.7)
not colonized	10 (16.7)	7(11.7)	7 (11.7)	4 (6.7)
Total	16 (26.7)	19 (31.7)	14 (23.4)	11(18.3)
Wearing of masks				
colonized	4 (6.7)	8 (13.3)	10 (16.7)	7 (11.7)
not colonized	17 (28.3)	7 (11.7)	1 (1.7)	1 (1.7)
Total	21 (35.0)	15(25.0)	11 (18.3)	8 (13.3)
Hand washing				
colonized	7 (11.7)	6 (10.0)	13 (21.7)	6 (10.0)
not colonized	9 (15.0)	8 (13.3)	6 (10.0)	5 (8.3)
Total	16 (26.7)	14 (23.3)	19 (31.7)	11(18.3)

On studying of risk factors of staphylococcal colonization among participants, it was found that there was no significant association between prevalence of Staphylococcal colonization and the duration of work, antibiotic use in the preceding month, infection control training, smoking or diabetes mellitus (P> 0.05) as shown in table (5).

Table 5: Staphylococcal colonization in HCWs in Burn and Surgical ICU units in Menoufia University hospitals by risk factors of infection

Risk factors	**Staphylococcal colonization**				χ^2	**P**
	Present (n=32)		**Absent (n=28)**			
	N	**(%)**	**N**	**(%)**		
Duration of work (years):						
≤ 5 (n=28)	7	21.9	14	50.0		
6-10 (n=17)	15	46.9	8	28.6	5.22	0.073
>10 (n=15)	10	31.2	6	21.4		
Antibiotic use in the preceding month:	13	33.3	8	38.1	0.01*	0.932
Infection control training	17	43.6	15	71.4	3.21*	0.073
Smoking	7	21.9	11	39.3	1.41*	0.236
Diabetes mellitus	2	6.3	3	10.7	0.02*	0.876

*Yates corrected X

DISCUSSION

In the present study, high prevalence (53.3%) of *S. aureus* colonization was found among HCWs in Surgical ICU and Burn Units in Menoufia University Hospital. None of them developed a clinical infection. The high prevalence rate occurred as the screening was done during an outbreak with prolonged contact with the patients. This proves that *S. aureus* remains one of the most frequently encountered nosocomial pathogen.[13] In a similar study in Egypt, *S. aureus* was isolated from 45.0% of HCWs in ICUs but the screening wasn't done during outbreak.[14] Also, higher nasal carriage rate (85.7%) for *S. aureus* among HCWs has been reported in Yemen, [15] while in two Pakistani studies the prevalence rates were 33% and 48%.[16,17] The prevalence of nasal carriage of *S. aureus* in other countries as Brazil was different (25.7%).[18] This difference may be due, in part, to differences in geographical distribution, differences in the quality and size of samples. Among nose and hands *S. aureus* isolates, 22/32 (68.8%) were *MRSA* strain. The overall *MRSA* carriage rate was 36.7%. Accurate and rapid detection of *MRSA* is important not only for choosing appropriate antibiotic therapy for the individual patient; but also for control of the endemicity of *MRSA*.[19] A similar

study in Egypt reflected that *S. aureus* was isolated from 18 HCWs (45%), 12 (66.6%) were *MRSA* strains. The overall *MRSA* carriage rate was 30%. Highest rate was in burn ICU (44.4%).[14] Similarly, Abdel Monem[15] reported that out of the 60 *S. aureus* carriers, 39 (65%) carried MRSA. Also, Naseer and Jayaraj,[20] found that among 327 *S. aureus* strains, 255 (77.9%) MRSA was detected. While, Akoua *et al*,[21] conducted a similar study and reported 45.5% carriage rate of *S. aureus*, out of which 38.7% strains were resistant to methicillin, whereas Alghaithy et al,[22] reported 26.1% S. aureus carriage, out of which 18.3% were *MRSA*.

In contrast, this carriage rate is very high compared to previous studies done in pediatric ICU in Philippine (7.7%).[23] Also, in the studies of Mainous *et al*,[24] the prevalence of *MRSA* among *S. aureus* isolates was 2.58%.

In the present study, Gram negative bacilli were isolated from 33.4% of HCWs. This finding was in agreement with those of Waters et al, who reported that Gram negative bacilli were isolated from hand of 38% of nurses.[25]

The high carriage rate of *MRSA* among HCWs in Surgical ICU (73.3%) in our study could be attributed to the high prevalence of this strain among patients in this unit as antibiotics were routinely prescribed to almost all patients preoperatively which may hasten the development of resistant organisms. Moreover, these patients commonly have indwelling devices and the healing surgical wound may act as a good media for growth of *MRSA*. In addition, post-operative hospital stay in surgical wards lengthens patients total hospital stay in comparison to other departments, thus increasing transmission between patients and HCWs.[26] Also, ICUs are particularly appropriate for the rapid emergence and spread of these pathogens because of the wide variety of pressure; which include frequent use of broad spectrum antibiotics, crowding of patients with high levels of disease acuity in a relatively small area.[27]

These results coincide with Warren et al,[28] who reported that *MRSA* has become predominant form of clinically significant *S. aureus* within the ICUs. Also, Klevens et al, stated that more than 70% of *S. aureus* isolated from ICUs were *MRSA*.[29]

As regards occupation, there were no significant differences in staphylococcal bacterial colonization, as both of them were exposed to patients. On the contrary, Abdel Monem[16] reported that occupation (doctors, nurses and auxiliary nurses) showed significant association with the nasal carriage of *MRSA* and MSSA and this may lead to cross-contamination of *MRSA* between personnel and patients. Also, Askarian et al.,[30] found that the only occupation found to have an association with the carrier status was having a nursing job, which increased the risk of nasal carriage of *MRSA* 3.6 folds.

According to the responses from the questionnaires administered, wearing of gloves and masks were the most protective measures applied by HCWs. Otherwise compliance with hand hygiene was neglected. HCWs reported some hindrances to their smooth functioning such as understaffing, overcrowding, and inadequate supply of equipment for patient care. This may be one of the leading factors of high carriage rate of S. *aureus* in the current study. Ho et al[31] reported that hand hygiene of the medical staff was the most important precaution for nosocomial infections. Limited resources especially for hand hygiene and deficient barrier equipment were the main causes for suboptimal infection control practice mentioned by most HCWs. Also, Boyce et al reported that suboptimal infection control practices have a strong influence on the possibility of transmission between patients and HCWs. These include; failure to perform active surveillance cultures to identify colonized patients, HCWs compliance with hand hygiene and use of protective barrier equipment.[32]

In the present study, duration of work, receiving antibiotics in the preceding month, infection control training, smoking and diabetes mellitus weren't risk factors for Staphylococcal carriage by HCWs. These results may be due to small sample size of the study population. These results were in agreement with Abdel Monem.[16] who found that there was no significant difference between nasal carriage of *MRSA* and MSSA with regard to sex, age, smoking habits, ischemic heart disease, chronic obstructive pulmonary disease (COPD) and antibiotic use through the last three months and diabetes mellitus. Similarly, Rahbar et al, (33) found no association between years of service and nasal carriage rate of *MRSA*.

In contrast, Eveillard et al,[34] found higher prevalence of *MRSA* carriage among HCWs when their length of service exceeded 5 years. Similarly, Egwuatu et al,[35] observed that HCWs with greater than 10 years of service were more likely to harbor *MRSA*. This observation could reflect a longer exposure to patients colonized or infected with *MRSA*. Also, antibiotic use in the preceding month was a risk factor for carriage of *S. aureus*.

The MRSA isolates from the current study were resistant to most of the antibiotics tested except amikacin, chloramphenicol, vancomycin and ceftriaxone indicating how dangerous these isolates could be if transmitted to the critically ill patients in surgical ICU. The greater resistance offered by isolates against commonly used antibiotics could be attributed to many factors like misuse and overuse of antibiotics. Decolonization of nasal colonized HCWs with mupirocin has been recommended by most

guidelines, but critical questions have arisen about the systematic use of this antibacterial agent. Work restrictions for HCWs colonized with *MRSA* differ geographically, ranging from being allowed to work without restrictions other than compulsory hand hygiene, to being removed from clinical duties or being forced to take leave of absence[(4)].

The present study was limited to a small sample size as only two departments in the hospital were included due to the outbreaks of *S. aureus* and *MRSA*. So, we recommend future studies for screening of HCWs in all departments of Menoufia University Hospitals to clarify the results. Another limitation is the non- availability of the mecA gene detection method (PCR) that is gold standard method for *MRSA* detection, but cefoxitin disc diffusion test was considered a sensitive method for detecting *MRSA* isolates.[(36)]

CONCLUSION AND RECOMMENDATIONS

The present study revealed that HCWs who have contact with patients are at risk of acquisition and colonization with *S. aureus* and its resistant strain. *MRSA* isolates were sensitive to amikacin, chloramphenicol, vancomycin and ceftriaxone. None of the socio-demographic or clinical characteristics of HCWs are related to carriage. Training of HCWs on hygienic measures especially proper hand hygiene is the key to overcome *S. aureus* infection in ICUs and Burn units.

Conflict of interest

All authors declares no conflict of interest

REFERENCES

1. Thomas J, Douglas G, David H, Donald E. Pneumonia, Harrison's principles of Internal Medicine, 16th edition, Vol II. London: McGraw-Hill publication, 2005;1539.
2. Lee G, Bishop P. Nosocomial infections. In: Lee G, Bishop P (eds). Microbiology and infection control for health professionals. New Jersey: Prentice Hall, 1997; 269.
3. MRSA, Guideline for the control of MRSA. MRSA task force of the greater Omaha area chapter of the association for professionals in infection control and epidemiology, Inc. 2010. Cited from: http://www.goapic.org/MRSA.htm
4. Albrich W, Harbarth S. Healthcare workers: Source, vector or victim of MRSA. *Lancet Infect Dis.* 2008; 8: 289-301.
5. Holmes A., Ganner M, McGuane S, Pitt T, Cookson B, Kearns A. *Staphylococcus aureus* isolates carrying Panton-Valentine leucocidin genes in England and Wales: Frequency, characterization and association with clinical disease. *J Clin Microbiol*. 2005; 43: 2384-90.
6. Shorr A, Tabak Y, Johannes R, Gupta V, Liu L, Kollef M. Morbidity and cost burden of methicillin-resistant *Staphylococcus aureus* in early onset ventilator associated pneumonia. Crit Care. 2006; 10: 1-7.
7. Lisa D, Petra G, Frank S, Ralf-Peter V. Health care workers causing large nosocomial outbreaks: a systematic review. BMC Infectious Diseases. 2013; 13:98,
8. Burden M, Cervantes L, Weed D, Keniston A, Price CS, Albert RK. Newly cleaned physician uniforms and infrequently washed white coats have similar rates of bacterial contamination after an 8-hour workday: a randomized controlled trial. J Hosp Med. 2011; 6: 177-82.
9. Preetha A, Prabha U, Hiresave S, Vijay J. Screening of Burns Unit staff of a Tertiary Care Hospital for methicillin-resistant *Staphylococcus aureus* colonization. *MJM.* 2000; 5 (2): 80-4.
10. Duckworth G. Diagnosis and management of methicillin resistant *Staphylococcus aureus*. BMJ. 1993; 307: 1049-52.
11. Cheesbrough M. Medical laboratory manual for tropical countries. Microbiology Part II. 2nd (ed). New York: Cambridge University Press, 2004: 1-9.
12. Clinical and Laboratory Standards Institute (CLSI). Performance standards for antimicrobial susceptibility testing CLSI approved standard M 100 – S15, Wayne, PA. 2005
13. Hetty E, Annet T, Titia E, Ada C, Christina M, Annemarie J et al. Role of healthcare workers in outbreaks of methicillin-resistant *Staphylococcus aureus*: a 10-years evaluation from a Dutch University Hospital. *Infect Control Hosp Epidemiol*. 2003; 24: 679-85.
14. Mansour M, Abd Rahman S. Colonization by methicillin resistant *Staphylococcus aureus* among health care workers in intensive care units. *Egyptian Journal of Medical Microbiology*. 2006; 15 (3): 531-9.
15. Abdel Monem M. Nasal Carriage of *Staphylococcus aureus* among Healthcare Workers in Althawra Hospital, Taiz City, Republic of Yemen**.** *Aust J Basic & Appl Sci.* 2012; 6(7): 417-24.
16. Naheed A, Saima S, Mobina D, Hayat A. Nasal carriage of Staphylococcus aureus in health care workers in Rawalpindi General Hospital. *J Rawal Med Coll*. 2002; 6: 74-6.
17. Kalsoom F, Zermina R, Akhtar N, Abdul Sattar, Jamshaid A, Bushra N. Nasal carriage of staphylococci in healthcare workers: antimicrobial susceptibility profile. *Pak J Pharm Sci*. 2008; 21 (3):290-4.
18. Silva E, Antas M, Monteiro B , Rabelo M, de Melo F , Maciel M. Prevalence and risk factors for *Staphylococcus aureus* in health care workers at a University Hospital of Recife-PE. *Braz J Infect Dis*. 2008; 12 (6): 504-8.
19. Skov R, Smyth R, Kahlmeter G. Evaluation of a cefoxitin 30μgdisc on ISO – Sensitest agar for detection of MRSA.*J. Antimicrobchemother*. 2003; 52 (2):204-7.
20. Naseer B, Jayaraj Y. Nasal carriage of methicillin-resistant *Staphylococcus aureus* isolates from intensive care unit patients. *Res J Bio. Sci*. 2010; 5: 150-4.
21. Akoua K, Dje K, Toure R, Guessennd N, Acho B, Faye Kette H, et al. Nasal carriage of methicillin-resistant *Staphylococcus aureus* among health care personnel in Abidjan. *Dakar Med*. 2004; 49 (1): 70-4.
22. Alghaithy A, Bilal N, Gedebou M, WeilyA. Nasal carriage and antibiotic resistance of Staphylococcus aureus isolates from hospital and non-hospital personnel in Abha, Saudi Arabia. . *Roy Soc Trop Med H*. 2000; 94: 504–7.
23. Pablito M, Armi G, Noreen B, Gonzales M. Nasal Carriage of Staphylococcus aureus among pediatric health care workers in a Pediatric Intensive Care Unit. *PIDSP Journal*. 2012; 13 (1):44-50.
24. Mainous III A, Hueston W, Everett C, Diaz V. Nasal carriage of *S. aureus* in the United States, Annals of Family Medicine. 2006; 4: 132-7.
25. Water V, Larson E, Wu F, San G, Haas J, Cimiotti J, et al. Molecular epidemiology of Gram negative bacilli from infected neonates and HCWs hand in neonatal ICUs. *Clin. Infect Dis*. 2004; 38 (12): 1682-7.
26. Kampf G, Adena S, Rüden H, Weist K. Inducibility and potential role of *mec*A gene positive oxacillin susceptible *Staphylococcus aureus* from colonized health care workers as a source for nosocomial infections. J. Hosp. Infect. 2003; 54 (2): 124-9.

27. Cespedes C, Miller M, Lowy F. Differences between *Staphylococcus aureus* isolates from medical and nonmedical personnel. *J Clin Microbiol*. 2002; 40 (7): 2594-7.
28. Warren D, Nitin A, Cheri H. Occurrence of co-colonization or co-infection with vancomycin-resistant enterococci and methicillin-resistant Staphylococcus aureus in a medical intensive care unit. *Infect Control Hosp Epidemiol*. 2004; 25(2): 99-104.
29. Klevens R, Edwards J, Tenover F, McDonaldL, HoranT, Gaynes R. Changes in the epidemiology of methicillin-resistant *Staphylococcus aureus* in intensive care units in US hospitals, 1992-2003. *Clin Infect Dis*. 2006; 42:389-91.
30. Askarian M, Zeinalzadeh A, Japoni A, Alborzi A, Memish Z. Prevalence of nasal carriage of methicillin-resistant Staphylococcus aureus and its antibiotic susceptibility pattern in healthcare workers at Namazi Hospital, Shiraz, Iran. International Journal of Infectious Diseases. 2009; 13 (5): 241-7.
31. Ho ML, Seto WH, Wong LC, Wong TW. Effectiveness of multifaceted hand hygiene interventions in long-term care facilities in Hong Kong: a cluster-randomized controlled trial. *Infect Control Hos Epidemiol*. 2012; 33: 761-7.
32. Boyce J, Havill N, Kohan C, Dumigan D, Ligi C. Do infection control measures work for MRSA. *Infect control Hosp Epidemiology*. 2004; 25 (5): 395-401.
33. Rahbar M, Karamiyar M, Agazi R. Nasal carriage of MRSA among HCWs of an Iranian hospital. *Infect control Hosp Epidemiology*. 2003; 24: 236-7.
34. Eveillond M, Martin Y, Hidri N, Boussougant Y, Joly-Guillou ML. Carriage of MRSA among hospital employees: prevalence, duration and transmission to households. *Infect. Control Hosp Epidemiol*. 2004; 25: 114-20.
35. Egwuatu, C, Ogunsola F, Egwuatu T, Oduyebo O.O. Prevalence and risk factors for carriage of methicillin-resistant *Staphylococcus aureus* (MRSA) among healthcare workers in a tertiary institution in Nigeria. *IOSR-JDMS*. 2013; 8 (4): 09-13.
36. Velasco D, Tomas M, Cartelle M, Beceiro A, Perez A, Molina F, et al. Evaluation of different methods for detecting methicillin (oxacillin) resistance in Staphylococcus aureus. *Journal of Antimicrobial Chemotherapy* 2005; 55: 379–82.