Bulletin of Faculty of Science, Zagazig University (BFSZU)
e-ISSN: 1110-1555
Volume-2023, Issue-1, pp-192-207
https://bfszu.journals.ekb.eg/journal
Research Paper DOI: **10.21608/bfszu.2023.165536.1190**

==========

Molecular studies of Staphylococcus aureus carriage in healthcare workers, patients and inanimate object in some Zagazig hospitals

Gamal M.A.Lashin[1]; Eman Tohamy[1]; Heba A. Ahmed[2];Rofida Mahmoud bakry[1].

[1.] Botany and Microbiology Department, Faculty of Science, Zagazig University.
[2].Zoonoses Department, Faculty of Veterinary Medicine, Zagazig University.

ABSTRACT: **Investigating the prevalence of *Staphylococcus aureus*, particularly methicillin-resistant *S. aureus* (MRSA), in patients, healthcare workers (HCWs), and inanimate objects in the research area in Zagazig province was the main goal of the current study. *S. aureus* was analysed bacteriologically in samples taken from Zagazig University and El-Mabarrah Hospitals in Zagazig City, Sharkia Governorate, Egypt. The presence of nuclease (the *nuc* gene) was further verified in all S. aureus isolates using PCR. The presence of the *mec*A gene was then used by PCR to identify the MRSA isolates. 52 (16.5%) isolates of *S. aureus* were confirmed by the *nuc* gene amplification; of these, 14 (26.9%) were recognised as MRSA and 38 (12.1%) as non-MRSA isolates based on the nuc gene amplification. We found the percent of two groups which lower than forty five years old and higher than fifty five was (37.5%), female is (87.5%) more than male percent (12.5%).**

Date of Submission: 24-10-2021 Date of acceptance: 1-03-2022

I. INTRODUCTION

Staphlococcus aureus is a facultative, Gram-positive, anaerobic, non-motile, and non-spore-forming bacteria. In hospitalised patients, staphylococcal infections are common and have serious implications.(1) Penicillin was first introduced in 1940, and strains of S. aureus resistant to it were first documented in 1945. (2,3) Hospital and community acquired infections are frequently caused by *S. aureus*. When bacteria obtain new genetic material encoding new proteins, they develop resistance. resistance. Methicillin-resistant *Staphlococcus aureus* MRSA strains have proliferated in hospitals all around the world over the past ten years. (4) MRSA predominate in burn units, among blood isolates, and in intensive care nurseries (5). Longer hospital stays and lengthier antibiotic use are connected with infections brought on by MRSA strains. Healthcare personnel who have been colonised may serve as a reservoir for MRSA transmission to patients and other HCWs (6). Hand cleanliness and other preventative measures have been demonstrated to be successful in decreasing the transmission of MRSA in patients and healthcare workers (7). Thus, the role of MRSA carriers in the transmission of this pathogen is critical and healthcare workers who are at the interface between the hospital and the community may serve as agents of cross transmission of hospital acquired MRSA and community acquired MRSA (8). In reality, between 5 and 10 percent of all patients admitted to contemporary medical facilities in wealthy nations and up to 25 percent in developing nations. Infections linked to health care are 2 to 20 times more likely to occur in developing nations than in wealthy ones **(9)**.

II. MATERIALS and METHODS

2.1.Sampling

At Zagazig University and El-Mabara Hospital in Zagazig City, Sharkia Governorate, Egypt, 120 participants—doctors, nurses, employees (janitors), and patients (30 each)—were enrolled in the study. The research was done between January and December of 2017. Hand and nasal swabs from each participant were taken in order to

isolate S. aureus (total = 240). In addition, 75 swabs from inanimate objects in the hospitals were also evaluated, including 25 telephones, 15 walls or doors, 20 beds, and 15 baskets.

Sterile swabs were moistened in buffered peptone water (BPW, Himedia, M614-500G) and rolled on the examined surface and hands (10). After swabbing, they were immersed in tubes contained BPW and transported in ice box to the laboratory of Zoonoses Department, Faculty of Veterinary Medicine, Zagazig University. For nasal swabs, the anterior nares were sampled using sterile moistened cotton swabs by gentile rotation for 5 times to a depth of 1 cm. Nasal swabs were then immersed in tubes containing BPW and transported in ice box to the laboratory.

2.2.Isolation and identification of S. aureus

The swabs that were put into the BPW were incubated for 16–18 hours at 37°C. The Baired Parker Agar (Himedia, M043-500G) was streaked with a loopful of the broth, and the plates were then incubated at 37°C for 16–18 hours.

Picked colonies were streaked onto nutritional agar (OXOID, CM0003) plates for further identification, and the plates were incubated at 37°C for 16–18 hours. Colonies that appeared black and surrounded by a clear halo zone were chosen. Then, purified and identified presumptive colonies using various biochemical tests (11).

2.3.Molecular identification of S. aureus isolates

DNA from the biochemically suspected isolates was extracted using QIAamP DNA MINI kit (QIAGEN, Catalougue no 5134) according to the manufacturer's guidelines. Primers specific for nuc gene (ATATGTATGGCAATCGTTTCAATGTAAATGCACTTGCTTCAGGAC) were used to identify *S. aureus* isolates.

The reaction was performed in a volume of 25 µl containing 12.5 µl of readymade power Emerald Amp GTPCR Master mix (Takara), 6 µl ofpurified DNA and 20 pmol of each primer (1µl, each) and 4.5µ l PCR grade water. A negative control (reaction mixture without adding DNA), and a positive control (provided by the Reference laboratory for Veterinary Quality Control on Poultry production,(Animal Health Research Institute, Giza) were run in the reaction. The reaction conditions included primary denaturation at 94°C for 5 min followed by 35 cycles of secondry denaturation at 94°C for 30 sec, annealing at 55°C for 45 sec and extension at 72°C for 45 sec followed by a final extension at 72°C for 10 sec. After amplification of each product, 1.5% agarose gel was prepared in 1x TBEand stained with 5 µM Ethidium Bromide (Sigma)**.** The PCR products (10 µl, each) were mixed with loading buffer (3 µl) and loaded in the gel beside 5 µl of 100 bp DNA ladder (Qiagen, USA). The gel was then run in 1x TBE and 5 µM Ethidium Bromide for 45 min at 100 volts and exposed to Ultra Violet light of ultraviolet trans-illuminator (Gel Documentation System, Alpha Innotech). For the MRSA species identification, *mec*A primers (GTA GAA ATG ACT GAA CGT CCG ATA A CCA ATT CCA CAT TGT TTC GGT CTA A) were used (12). The reaction conditions of *mec*A PCR included primary denaturation at 94°C for 5 min followed by 35 cycles of secondry denaturation at 94°C for 30 sec, annealing at 55°C for 45 sec and extension at 72°C for 45 sec followed by a final extension at 72°C for 10 sec

2.4.Risk factors analysis

Age, sex, occupation, underlying illnesses, years of experience (for doctors, nurses, and labourers), disease, interaction with MRSA patients, and antibiotic delivery were all covered in the questionnaire.

In order to identify variables linked to S. aureus and MRSA infection, a bivariate logistic regression model was built. Version 22 of SPSS, Inc. was used for the analysis (IBM Corp. 2013) The crude odds ratio (COR) and its 95% confidence interval (CI) were recorded. P values of 0.05 or below were regarded as statistically significant..

2.5. Statistical analysis

The difference in *S. aureus* prevalence among the examined samples was analyzed by Chi-squared test that was computed using R-package for statistics (Rx64 3.1.1.). Differences were considered to be significant at

P<0.05. For the tested values containing expected frequencies of less than five, Fisher's exact test was used instead of Chi-squared test.

rtorius/Germany).

III. RESLUTS And DISCUSSIONS

3.1.Isolation and Identification of Staphylococcusisolates

One hundred and twenty participants were enrolled in the current study. Patients (n=30) and health care workers (n=90) comprising of doctors, nurses and janitors (30, each) were examined for nasal and hand carriage of S. aureus and MRSA. Inanimate objects in the visited hospitals were also examined (n=75). Suspected Staphylococcus spp. was identified by their colonial morphology on Paired Parker Agar. The colonies appeared black surrounded by a clear halo zone. Out of the examined samples (n=315), 175 (55.6%) were suspected as *Staphylococcus* spp. based on the growth on the culture media.

3.2.Biochemical identification

The isolates suspected by the colony morphology as *Staphylococcus* spp. (n=175) were subjected to biochemical examination using different tests **(Table 1)**. The results revealed that 130 (41.3%) isolates were biochemically suspected as *S. aureus*. Coagulase test of the suspected isolates confirmed that 86 (27.3%) were coagulase positive (3).

3.3.Molecular identification

Identification of *S. aureus* was carried out by the amplification of *nuc* gene which produced 395 bp **(Figure 1A)** (4), while, MRSA isolates were characterized by the amplification of *mec*A gene with 310 bp amplicon **(Figure 1B)**. The amplification of *nuc* gene identified 52 (16.5%) isolates as *S. aureus*, of which, 14 (26.9%) were classified as MRSA and 38 (12.1%) as non-MRSA isolates based on the amplification of the *mec*A gene.

3.4.Prevalence of *S. aureus* and MRSA in the examined samples

3.4.1.Prevalence of *S. aureus* and MRSA in nasal swabs of patients and healthcare workers

Overall, 20% (24/120) of nasal swabs from patients and healthcare workers were positive for *S. aureus*, and, 5.3% were positive for MRSA **(Table 2)**. Patients and janitors had the higher isolation rates of *S. aureus* (23.3%, each), followed by nurses (20%) and doctors (13.3%). However, no significant difference was observed for the isolation rate of *S. aureus* among the examined groups (p=0.741). For MRSA, doctors had the lower isolation rate (3.3%) compared to the other groups (6.7%) with no significant difference (p=1).

3.4.2.Prevalence of S. aureus and MRSA in hand swabs of patients and healthcare workers

A total of 10% (12/20) hand swabs from patients and healthcare workers were positive for *S. aureus*, while, 2.5% were positive for MRSA **(Table 2).** *S. aureus* were recovered from hand swabs of janitors with non-significant higher isolation rate than patients (13.3%) and nurses (10%). While, MRSA percentages in nurses, janitors and patients were 3.3%, each.

3.4.3Proportion of S. aureus and MRSA in inanimate objects

The occurrence of *S. aureus* in inanimate objects was 21.3%, while, 5.3% were positive for MRSA strains **(Table 3)**. The percentages of *S. aureus* recovered from baskets (40%) were higher than walls /doors (20%), cellphones (16%) and beds (15%), although the difference was non- significant. MRSA strains were isolated from all the objects with percentages ranging from 4-6.7% with no statistical significant difference.

3.5.Risk factors associated with S. aureus and MRSA infection

The following table provides an overview of the risk variables and demographic information related to S. aureus infection among the participants (**Tables 4**). Participants who were female had a propotional of 67.5 percent,

while men had a propotional of 32.5 percent. The plurality (44.2%) of those older than 41 were in the age range of 26 to 40. (31.7 percent). 42.5 percent of the individuals had undergone antibiotic treatment, and 69.2 percent of them had a history of sore throats. Participants under the age of 41 were more likely to get the disease (P = 0.001). Additionally, participants who had previously taken antibiotics had a 2.8-fold higher risk of contracting S. aureus infection than those who had not (OR=2778, 95 percent CI: 1.103-6.998, P=0.03). Other variables like gender, education, occupation, and place of residence had little bearing on getting infected with S. aureus.

Table (1): Biochemical tests for the identification of *S. aureus* isolates

Test	Result
Gram stain	Positive cocci
Oxidase	Negative
Catalase	Positive
Citrate	Positive
Gelatin liqufication	Positive
Methyl Red	Positive
Vogusproskauer	Positive
Indole	Negative
Nitrate reduction	Positive
Urease	Positive
Coagulase	Positive
H_2S	Negative
Motility	Non motile

Table (2): Proportion of *S. aureus* and MRSA among patients andhealthcare workers

Subjects	Description	Type of swabs	Examined number	*S. aureus* positive (%)	Non- MRSApositive (%)	MRSA positive (%)
Patients	Resident patients	Nasal	30	7 (23.3%)	5 (16.7%)	2 (6.7%)
		Hand	30	4 (13.3%)	3 (10%)	1 (3.3%)
HCWs	Nurses	Nasal	30	6 (20%)	4 (13.3%)	2 (6.7%)
		Hand	30	3 (10%)	2 (6.7%)	1 (3.3%)
	Janitor s	Nasal	30	7 (23.3%)	5 (16.7%)	2 (6.7%)
		Hand	30	5 (16.7%)	4 (13.3%)	1 (3.3%)
	Doctors	Nasal	30	4 (13.3%)	3 (10%)	1 (3.3%)
		Hand	30	0 (0%)	0 (0%)	0 (0%)
	Total	Nasal	90	17 (18.9%)	12 (13.3%)	5 (5.5%)
		Hand	90	8 (8.9%)	6 (6.7%)	2 (2.2%)
Overall		Nasal	120	24 (20%)	17 (14.2%)	7 (5.3%)
		Hand	120	12 (10%)	9 (7.5%)	3 (2.5%)

The percentages of *S. aureus*, non-MRSA and MRSA isolates are calculated based on theexamined samples. HCWs: Healthcare workers

Table (3): Proportion of *S. aureus* and MRSA in inanimate objects

Samples	Examined number	*S. aureus* positive (%)	Non-MRSA Positive (%)	MRSA positive(%)
Cell phones	25	4 (16%)	3 (12%)	1 (4%)
Walls/Doors	15	3 (20%)	2 (13.3%)	1 (6.7%)
Beds	20	3 (15%)	2 (10%)	1 (5%)
Baskets	15	6 (40%)	5 (33.3%)	1 (6.7%)
Total	75	16 (21.3 %)	12 (16%)	4 (5.3%)

The percentages of *S. aureus*, non-MRSA and MRSA isolates are calculated based on theexamined samples.

Table (4): Risk factors and demographatic data associated *with S. aureus* infection in the participants (n=120)

Risk factor		No of participants	*S. aurus*		COR 95%(CIF:lower-upper)	p.value
			Positive	Negative		
Age	<15	14 (11.7%)	0	14 (100%)	-	-
	16-25	15 (12.5%)	0	15 (100%)	-	-
	26-40	53 (44.2%)	5 (4.9%)	48 (90.6%)	0.104 (0.034-0.319)	<0.001
	≥41	38 (31.7%)	19 (50%)	19 (50%)	1	-
Gender	Male	39 (32.5%)	3 (7.7%)	36 (92.3%)	0.238 (0.066-0.855)	0.28
	Female	81 (67.5%)	21 (25.9%)	60 (74.1%)	1	-
Education	High	62 (51.7%)	11 (17.7%)	51 (82.3%)	0.503 (0.158-1.601)	.245
	Others	38 (31.7%)	7 (18.4%)	31 (81.6%)	0.527 (0.149-1.857)	0.319
	Illiterate	20 (16.7%)	6 (30%)	14 (70%)	1	-
	Patients	30 (25%)	7 (23.3%)	23 (76.7%)	1 (0.302-3.308)	1

Occupation	Doctors	30 (25%)	4 (13.3%)	2.6 (86.7%)	0.505 (0.131-1.951)	0.322
	Nurses	30 (25%)	6 (20%)	24 (80%)	0.821 (0.240-2.814)	0.754
	Workers	30 (25%)	7 (32.3%)	23 (76.7%)	1	-
Residence	Rular	38 (31.7%)	8 (21.1%)	30 (78.9%)	1.1 (0.425-2.85)	0.844
	Urban	82 (68.3)	16 (19.5%)	66 (80.5%)	1	-
Administration of antibiotic	Yes	51 (42%)	15 (29.4%)	36 (70.9%)	2.778 (1.103-6.998)	0.03
	No	69 (57.5%)	9 (13.04%)	60 (86.9%)	1	-
History of sore throat	Yes	83 (69.2%)	17 (20.5%)	66 (79.5%)	1.104 (0.414-2.942)	0.843
	No	37 (30.8%)	7 (18.9%)	30 (81.1%)	1	-

COR: Crude Odds Ratio, CI: Confidence Interval

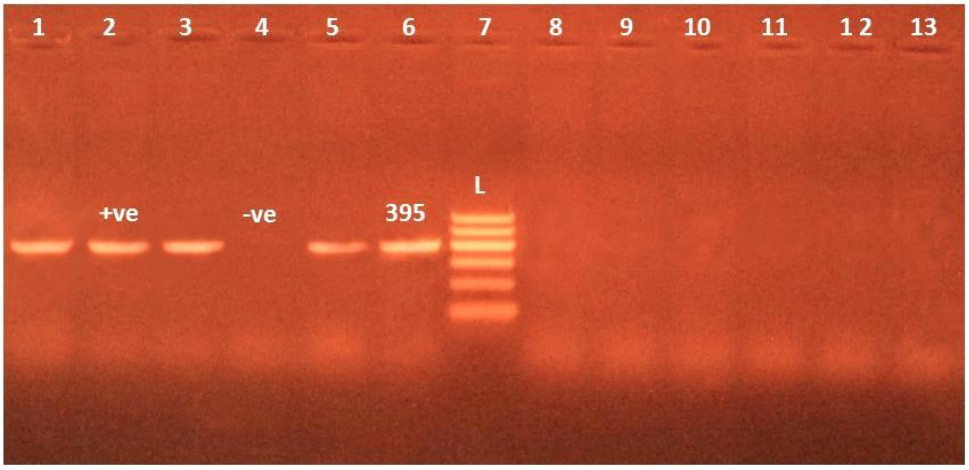

Figure 1: Agarose gel (1.5%) showing amplified products of *nuc* gene from *S. aureus* isolates (395 bp). Lane: DNA molecular size marker (100 bp). Lanes (1-3, 5): positive samples, lane 6: positive control, lane 8: negative control, lanes (4,9-12) : negative samples.

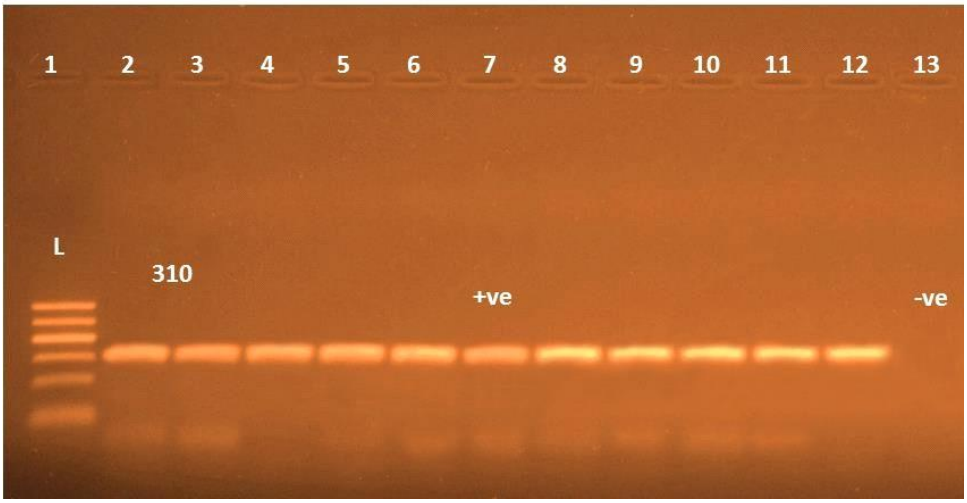

Figure 2: Agarose gel (1.5%) showing amplified products of *mec*A gene from *S. aureus* (310 bp). Lane: DNA molecular size marker (100 bp). Lanes (2-11): positive samples, lane 12: positive control, lane 13: negative samples.

.

IV. DISCUSSION

Staphylococcus aureus causes life-threatening infection in both healthy individuals and patients especially those seeking health care. *S. aureus* has been known as a common cause of various community acquired and nosocomial infections (13).

4.1.Nasal carriage

Nasal carriage of *S. aureus* appears to play a key role in the epidemiology and pathogenesis of infection **(1)**. In the current study, the overall nasal carriage of *S. aureus* in patients and HCWs was 20% in the examined samples. In accordance, an isolation rate of *S. aureus* was reported in patients and HCWs in West Bank of Palestine.

(25.4%) **(14)** and HCWs in Kuwait (15.8%) **(15)**.

The nasal carriage of *S. aureus* in patients in the current study was 23.3%, which was higher than 5% in England **(16)**, and 12.7% in Belgium **(17)**. In Egypt, *S. aureus* nasal carriage was detected in 52% of patients attending primary healthcare centers **(18)**.

Health care workers (HCWs) act as a potential source of *S. aureus* infection especially to immunocompromised patients, resulting in their extended stay in hospitals **(19)**. In the current study, the nasal carriage of *S. aureus* in HCWs was 18.9%. Comparable nasal carriage rates of HCWs were reported, for instance;17.5% in India **(20)**, 18.1% in Turkey **(21)** and 18.3% in Kenya (**22)**, 22.2% in India **(23)**, 25% in Nepal **(24)** and 28.8% in Ethiopia **(7)**. Different studies have also reported higher isolation rates of *S. aureus* between HCWs; 31% in Iran **(25)**, (18.1%) in Turkey **(21)**, 40.4% in Ukraine **(26)**, 48% in Pakistan
(27), 33.8% in Germany **(28)**, 42.1% and (31%) in Palestine **(29, 30)**, 34.8% in UK **(16)** and 33% and 43.8% in USA **(31, 32)**. Lower isolation rates were also reported between HCWs; 13% in India **(33)**, 17.5% in India **(20)**.

In the current study, the nasal carriage percentages of *S. aureus*between HCWs were 13.3% in doctors followed by 20% in nurses and 23.3% in janitors, which may be attributed to more patient contacts between janitors and nurses than doctors in Egypt, however, the differencebetween the groups was non-significant. In contrary, **(8)** and **(34)** attributed the highest isolation rates of *S. aureus*between doctors, to the direct physical contact with patients. Other studies reported high isolation rates between nursing staff; 39.4% in Sri Lanka **(35)** and 40.3% in UK **(16)**. The difference between studies might be due to the degree of direct contact with patients and different groups of HCWs.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is one of the leading causes of both health care-associated infections and community associated infection **(36)**. The carriage of MRSA, is well known to be a significant risk factor for subsequent infections **(37)**.

The prevalence of MRSA varies from hospital to hospital in various countries and is constantly rising in many countries raising public health concerns. In many American and European hospitals, the percentage of MRSA carriage has ranged from 29% to 35% **(38,39)**. The incidence of MRSA indeveloping countries such as India ranges from 30% to 70% **(40, 41)**.

Based on the results of many studies performed to identify MRSA, it was reported that Cefoxitine antibiotic is better than Oxacillin in MRSA identification **(42, 43, 44, 45)**. Thus, MRSA isolates in the current study were identified by cefoxitin disc resistance, and then confirmed by PCR targeting the *mec*A gene. The *mec*A gene is located on a mobile genomic island Staphylococcal cassette chromosome (SCC), which not only serves as a vehicle for the genetic exchange of genes among Staphylococci, but also as a carrier for virulence and additional drug resistant genes **(46, 47**). In accordance, **(26)** and **(48)** reported that all MRSA isolates were positive for *mec*A gene. The overall nasal carriage of MRSA in the current study was 5.3%. Comparable prevalence rates were reported in India (6.6%) **(49)** and UK (6.2%) **(50)**, in Nepal (7.1%) (**24)** and KSA (8%) **(51)**.

Our results revealed that 6.7% of the patients carried MRSA in their anterior nares. MRSA isolation rates were documented in Taiwan (3.6%) **(52)**, in India (2.5%) **(20)** and Ukraine (3.7%) **(26)**. On the other hand, **(21)** and **(34** reported that none of nasal swab samples collected from patients were positive for MRSA.

Different studies reported higher prevalence rates of MRSA; 20% in Greece **(52**), 38.9% in Nigeria **(53)**, 15.1%in Oman **(54)**,14.2% in Egypt **(55)**, 31.8% in KSA **(51)**, 34.1% in Bangladesh **(56)** and 40.1% in Tunisia **(57)**.

The prevalence rate of MRSA in patients (6.7%) in the current study was lower than the percentages obtained in different studies. In Egypt, **(58)** reported that MRSA prevalence was 36% in patients attending a hospital in Alexandria. More recently, **(18)** in Egypt and KSA, reported that MRSA nasal carriers between patients were 32% and 25%, respectively. Authors attributed that to the type of patients included in studies, which included inpatients and outpatients with skin and soft tissue infections. Others factors could be responsible for the higher carriage rate of MRSA including the overconsumption of antibiotics in Egypt, which is a contributing factor for multidrug resistant bacteria.

The MRSA nasal carriage among HCWs in the current study was 5.5%. Comparable isolation rates were observed for instance; in Taiwan (5%) **(59)**, USA (6.6%) **(31**), Serbia (7.6%) **(60)** and UK (6%) **(16)**. On the other hand, higher isolation rates were observed in KSA (73%) **(71)**, Ethiopia (12.7%) **(7)**, Palestine (22.6% and 25.5%) **(29, 30)** and Nepal (21.9%) **(34)**, while, lower isolation rates were reported in Turkey(1.8%) **(61)** and India (2.5%) **(20)**.

In the current study, no MRSA was detected in (0%) doctors, while its prevalence between nurses and janitors was 20% and 23.3%, respectively. Also, **(16)** reported that no MRSA isolates were detected in doctors, while higher prevalence rates were detected in other studies; 16% in Palestine **(30)**, 12.7% in Ethiopia **(7)** and 65.2% in Nigeria (**8)**. Regarding other HCWs (nurses and janitors), different studies reported nasal carriage of MRSA; 14.3% in India for both nurse and janitors **(20)**, 21.2% in Ethiopia for nurses **(7)**, 11.9% in Sri Lanka for nurses (35), 30.4% in Palestine for nurses **(30)**, 7.8% in Nepal for nurses (Khanal et al., 2015), 3.6% in Taiwan for hospital janitors **(37)**, 6.9% in USA for nurses **(62)**, and 5% in UK for nurses **(16)** and 3.4% in Iran for janitors (**25**) and (**8).**

The higher nasal carriage of janitors compared to the studied participants should raise concerns of the health care workers of janitors and their families **(37).** Health education of janitors to follow infection control measures is essential to decrease the risk of spreading pathogens in the hospital environment and to the outside community.

High risk of colonization with MRSA strains among HCWs may be due to their frequent patient contact **(34)**. Many factors including local infection control standards, overcrowding, poor hygiene and nutritional status may play a role in MRSA colonization between HCWs **(44)**.

Nasal colonization of *S. aureus* and MRSA is different all over the world and differ within the same country and same hospital. Differences inthe prevalence may be explained in part by differences in the quality and size of samples, type of tested specimen, patient characteristics, the use of different microbiological methods, media used for isolation and different interpretation guidelines. Moreover, different levels of commitment toinfection control measures may contribute to these differences **(30, 55)**. Also, screening of the throat in addition to nasal swabs in some studies may increase the sensitivity of detection of
S. aureus among HCWs and patients by 20% to 26% **(63)**, and increase MRSA carriage rate by over 30% **(60)**. In addition, differences in study design, like duration of a study, investigation of particular populations, investigation during epidemics, investigation ina particular units (e.g. ICU), may have significant impact on obtained results **(60)**.

4.2.Prevalence in hand swabs and contact surfaces

Health care workers are considered the interface between the hospital environment and the outside environment **(8)**. Therefore, HCWs may serve as reservoirs and carriers of *S. aureus* and MRSA. Their hands are the most common which for the transmission of nosocomial pathoges from patient to patient and to other contacts. Studies have demonstrated pathogenic and potential pathogenic bacteria contaminated frequently hand and hand touched materials **(64, 65, 66, 67)**. The overall *S. aureus* prevalence in the current study in hands of patients and HCWs was 10%. Regarding HCWs, MRSA prevalence was 10% nurses and 16.7% janitors, while, MRSA prevalence was 2.5% from hands of patients and HCWs (3.3% from patients, janitors and nurses, each). No *S. aureus* or MRSA isolates were detected in doctor's hands.

Staphylococcus aureus prevalence rates in hand swabs of HCWswere reported in several studies, such as; 8.9% in Portugue **(68)** 6.3% in china **(69)**. 56.4% in Taiwan **(70)** and 26.2% in Turkey **(72).** On the other hand, the prevalence of MRSA was reported 31.6% in Cairo **(73)**

The use of cell phones and other inanimate objects by patients and HCWs not only demonstrated a high contamination rate with bacteria but also more importantly contamination with nosocomial pathogens **(72**). The *S. aureus* prevalence in the current study was 21.3% from inanimate objects; 16%, 40%, 20% and 15% from cellphone, basket, walls/doors and beds, respectively, and the MRSA prevalence was 4:6.7% from inanimate objects; 6.7%, 6.7%, 4% and 5% from cellphone, basket, walls/doors and beds, respectively. The higher contamination rate was observed in basket, as a result of contaminated substances thrown in it.The current study showed that *S. aureus* and MRSA were isolated from cellphones with percentages 16% and 6.7%, respectively.

Several studies showed various isolation rates of *S. aureus* from cell phone, for instances; (52%) **(72)** and (1.9%) in Turkey **(74, 72)**, 48% in Cairo (Elkholyet al., 2010), and 43.7% in India **(75)**. Other studies showed different prevalence rates of MRSA from cellphones, such as;13% in Turkey **(72)**, 21.05% in India **(75)**, 0.95% in Turkey **(74)** and 9% in Oman **(54)**. This variation may be due to the variation of the study participants in adherence to infection prevention, cell phone handling, mobile phone keeping habits and personal behavior including hand washing practice **(70, 76)**.

The contamination of cell phones with *S. aureus* and MRSA is crucial due to the ability of transmitting these organisms to hand, mouse, nose and ears **(73).** Consequently, these pathogens can then be transmitted to patients and other contants.

The contamination of inanimate objects with *S. aureus* and MRSA is risk for patients to acquire infections. Therefore, **(77)** control and hygienic measures should be followed to minimize the risk of acquiring infection due to environmental contamination.

4.3.Risk factors associated with *S. aureus* and MRSA nasalcarriage

Our result shows a significant likelihood of *S. aureus* and MRSA nasal carriage in the age group 26-40 years old followed by ≥41 years old. Otherfactors such as gender, education level, occupation, residence and history of sore throat had no effect on *S. aureus* and MRSA nasal carriage in patients and HWCs. No significant effect of age, education and gender, antibiotic therapy was observed on the nasal carriage of *S. aureus* in healthcare workers in Iran (**25**).

REFERENCES

1-Kluytmans, J., A. van Belkum and Verbrugh, H. (1997): Nasal carriage of Staphylococcus aureus: epidemiology, underlying mechanisms, and associated risks. *Clinical Microbiology Reviews*, 10, 505-520.

2-El-Din, S. A. S., E. El-Shafey, R. Mohamad ,M. El-Hadidy, A. El-Din, M. El-Hadidy and Zaghloul H. (2003): Methicillin-resistant Staphylococcus aureus: a problem in the burns unit. *Egyptian Journal of Plastic and Reconstructive Surgery*, 27, 1-10.

3-Korn, G. P., M. D. Martino, I. M. Mimica, L. J. Mimica, P. A. Chiavone and Musolino, L .R. d. S. (2001): High frequency of colonization and absence of identifiable risk factors for methicillin-resistant Staphylococcus aureus (MRSA) in intensive care units in Brazil. *Brazilian Journal of Infectious Diseases*, 5,1-7.

4-Lowy, F. D., (1998): Staphylococcus aureus infections. *The New England journal of medicine*,339, 520-532.

5-Chua, T., C. L. Moore, M. B. Perri, S. M. Donabedian, W. Masch, D. Vager, S. L. Davis, K. Lulek, B. Zimnicki and Zervos M. J. (2008): Molecular epidemiology of methicillin-resistant Staphylococcus aureus bloodstream isolates in urban Detroit. *Journal of clinical microbiology*, 46, 2345-2352.

6-Kirecci, E., A. Ozer, M. Aral and Miraloglu M. (2010): A Research of nasal methicillin resistant/sensitive Staphylococcus aureus and pharyngeal beta-haemolytic Streptococcus carriage in midwifery students in Kahramanmaras, Eastern Mediterranean Region of Turkey. *Ethiopian Journal of Health Development*, 24.

7-Shibabaw, A., T. Abebe and Mihret, A. (2013): Nasal carriage rate of methicillin resistant Staphylococcus aureus among Dessie Referral Hospital Health Care Workers; Dessie, Northeast Ethiopia. *Antimicrobial Resistance and Infection Control*, 2, 25.

8-Albrich, Werner C, H. , . and Stephan T.(2008): Health-care workers: source, vector, or victim of MRSA? *The Lancet infectious diseases*, 8, 289-301.

9-WHO, (2002): World Health organization. Department of communicable diseases surveillance and response.

10-Landers, T. F., A. Hoet and Wittum, T. E. (2010): Swab type, moistening, and preenrichment for Staphylococcus aureus on environmental surfaces. *J Clin Microbiol*, 48, 2235-2236.

11-Murray, P. R., E. J. Baron, M. A. Pfaller, F. C. Tenover and Yolken R. H. (1999): Manual of clinical microbiology 7thed. ASM Press,Washington.

12-McClure, J. A., J. M. Conly, V. Lau, S. Elsayed, T. Louie, W. Hutchins and Zhang, K. (2006): Novel multiplex PCR assay for detection of the staphylococcal virulence marker Panton- Valentine leukocidin genes and simultaneous discrimination of methicillin-susceptible from -resistant staphylococci. *J Clin Microbiol*, 44, 1141-1144.

13-Papa, R., M. Artini, A. Cellini, M. Tilotta, E. Galano, P .Pucci, A. Amoresano and Selan, L. (2013): A new anti-infective strategy to reduce the spreading of antibiotic resistance by the action on adhesion-mediated virulence factors in Staphylococcus aureus. *Microbial pathogenesis*, 63, 44-53.

14-Kaibni, M. H., M. A. Farraj, K .Adwan and Essawi T. A. (2009): Community-acquired meticillin-resistant Staphylococcus aureus in Palestine. *Journal of medical microbiology*, 58, 644-647.

15-Dimitrov, T., E. Udo and Grover S. (2003): Point surveillance of Staphylococcus aureus carriage among medical staff in Infectious Diseases Hospital, Kuwait. *Medical Principles and Practice*, 12, 139-144.

16-Price, J. R., ., K. Cole, ., A. Bexley, .ew, V. Kostiou, E. , David W, T. Golubchik, ., D. J. Wilson, ., D. W. Crook, ., A. S. Walker, . and Peto T. E. (2017): Transmission of Staphylococcus aureus between health-care workers, the environment, and patients in an intensive care unit: a longitudinal cohort study based on whole-genome sequencing. *The Lancet Infectious Diseases*, 17, 207-214.

17-Paling, F. P., M. Wolkewitz, L. G. Bode, P. K. Klouwenberg, D. Ong, P. Depuydt, L. De Bus, F. Sifakis, M. Bonten and Kluytmans, J. (2017): Staphylococcus aureus colonization at ICU admission as a risk factor for developing S. aureus ICU pneumonia. *Clinical Microbiology and Infection*, 23, 49. e49-49. e14.

18-Abou Shady, H. M., A. E. Bakr, M. E. Hashad and Alzohairy M. A. (2015): Staphylococcus aureus nasal carriage among outpatients attending primary health care centers: a comparative study of two cities in Saudi Arabia and Egypt. *The Brazilian journal of infectious diseases : an official publication of the Brazilian Society of Infectious Diseases*, 19, 68-76.

19-Malini, J., S. A. Harle, M. Padmavathy, B. Umapathy, B. Navaneeth, J. Keerthi Mannan and Girish, M. (2012): Methicillin-resistant Staphylococcus aureus Carriage among the Health Care Workers in a Tertiary Care Hospital. *Journal of Clinical & Diagnostic Research*, 6.

20-Radhakrishna, M., M. D'Souza, S. Kotigadde, V. Saralaya and Kotian S. (2013): Prevalence of methicillin resistant Staphylococcus aureus carriage amongst health care workers of critical care units in Kasturba Medical College Hospital, Mangalore, India. *Journal of clinical and diagnostic research: JCDR*, 7, 2697.

21-Oguzkaya Artan, M., M. Gulgun, Z. Baykan and Tok, **D.** (2008): Investigation of nasal carriage rates and antimicrobial susceptibility of Staphylococcus aureus in hospital staff. *Turkish J of Infection*, 22, 87-90.

22-Omuse, G., S. Kariuki and Revathi, **G.** (2012): Unexpected absence of meticillin-resistant Staphylococcus aureus nasal carriage by healthcare workers in a tertiary hospital in Kenya. *Journal of Hospital Infection*, 80, 71-73.

23-Rongpharpi, S. R., N. K. Hazarika and Kalita, H. (2013): The prevalence of nasal carriage of Staphylococcus aureus among healthcare workers at a tertiary care hospital in assam with special reference to MRSA. *Journal of clinical and diagnostic research: JCDR*, 7, 257.

24-Shakya, B., S. Shrestha and Mitra, **T.** (2010): Nasal carriage rate of methicillin resistant Staphylococcus aureus among at national medical college teaching hospital, Birgunj, Nepal. *Nepal Med Coll J*, 12, 26-29.

25-Askarian, M., A. Zeinalzadeh, A. Japoni, A. Alborzi and Memish Z. A. (2009): Prevalence of nasal carriage of methicillin-resistant Staphylococcus aureus and its antibiotic susceptibility pattern in healthcare workers at Namazi Hospital, Shiraz, Iran. *International Journal ofInfectious Diseases*, 13, e241-e2.47.

26-Netsvyetayeva, I., ., M .Fraczek, ., K. Piskorska, ., M. Golas, ., M. Sikora, ., A. Mlynarczyk, ., E. Swoboda-Kopec, ., W. Marusza, ., B. Palmieri, . and Iannitti, T. (2014): Staphylococcus aureus nasal carriage in Ukraine: antibacterial resistance and virulence factor encoding genes. *BMC infectious diseases*, 14, 128.

27-Farzana, K., Z. Rashid, N. Akhtar, A. Sattar, J. A. Khan and Nasir B. (2008): Nasal carriage of staphylococci in health care workers: antimicrobial susceptibility profile. *Pakistan journal of pharmaceutical sciences*, 21.

28-Kampf, G., S. Adena, H. Rüden and Weist K. (2003): Inducibility and potential role of mecA- gene-positive oxacillin-susceptible Staphylococcus aureus from colonized healthcare workers as a source for nosocomial infections. *Journal of Hospital Infection*, 54, 124- 129.

29-Al Laham, N. (2016): Detection and Antibiotic Resistance Pattern of Staphylococcus aureus and MRSA Isolated from Healthcare Workers Nares at Gaza Hospitals, Palestine. *The International Arabic Journal of Antimicrobial Agents*, 5.

30-El Aila, N. A., N. A. Al Laham and Ayesh B. M. (2017): Nasal carriage of methicillin resistant Staphylococcus aureus among health care workers at Al Shifa hospital in Gaza Strip. *BMC infectious diseases*, 17, 28.

31-Elie-Turenne, M.-C., H. Fernandes, J. R. Mediavilla, M. Rosenthal, B. Mathema, A. Singh, T. R. Cohen, K. A. Pawar, H. Shahidi and Kreiswirth B. N. (2010): Prevalence and characteristics of Staphylococcus aureus colonization among healthcare professionals in an urban teaching hospital. *Infection Control & Hospital Epidemiology*, 31, 574-580.

32-Ibarra, M., T. Flatt, D. Van Maele, A. Ahmed, J. Fergie and Purcell K. (2008): Prevalence of methicillin-resistant Staphylococcus aureus nasal carriage in healthcare workers. *The Pediatric infectious disease journal*, 27, 1109-1111.

33-Vinodhkumaradithyaa, A., A. Uma, M. Shirivasan, I. Ananthalakshmi, P. Nallasivam and Thirum P. (2009): Nasal carriage of methicillin-resistant Staphylococcus aureus among surgical unit staff. *Jpn J Infect Dis*, 62, 228-229.

34-Khanal, R., P. Sah, P. Lamichhane, A. Lamsal, S. Upadhaya and Pahwa V. K. (2015): Nasal carriage of methicillin resistant Staphylococcus aureus among health care workers ata tertiary care hospital in Western Nepal. *Antimicrobial resistance and infection control*, 4, 39.

35-Mahalingam, U., K. Thirunavukarasu and Murugananthan, K. (2014): Methicillin resistant Staphylococcus aureus among nurses in a tertiary care hospital in northern Sri Lanka. *Ceylon Medical Journal*, 59.

36-Weiner, L. M., A. K. Webb, B. Limbago, M. A. Dudeck, J. Patel, A. J. Kallen, J. R. Edwards and Sievert D. M. (2016): Antimicrobial-resistant pathogens associated with healthcare- associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2011–2014. *infection control & hospital epidemiology*, 37, 1288-1301.

37-Chang, C.-J., N.-C. Chen, C.-K. Lao and Huang Y.-C. (2015): Nasal Staphylococcus aureus and methicillin-resistant S. aureus carriage among janitors working in hospitals in Northern Taiwan. *PloS one*, 10, e0138971.

38-Brumfitt, W. and J. Hamilton-Miller (1989): Methicillin-resistant Staphylococcus aureus. *New England Journal of Medicine*, 320, 1188-1196.

39-Tenover, F. C., J. W. Biddle and Lancaster M. V. (2001): Increasing resistance to vancomycin and other glycopeptides in Staphylococcus aureus. *Emerging infectious diseases*, **7,** 327.

40-Verma, S ,.S. Joshi, V. Chitnis, N. Hemwani and Chitnis D. (2000): Growing problem of methicillin resistant staphylococci--Indian scenario. *Indian journal of medical sciences*,**54,** 535-540.

41-Rajaduraipandi, K., K. Mani, K. Panneerselvam, M. Mani, M. Bhaskar and Manikandan P. (2006): Prevalence and antimicrobial susceptibility pattern of methicillin resistant Staphylococcus aureus: A multicentre study. *Indian journal of medical microbiology*, 24, 34.

42-Crémieux, A.-C., O. Dumitrescu, G. Lina, C. Vallee, J.-F. Côté, M. Muffat-Joly, T. Lilin, J. Etienne, F. Vandenesch and Saleh-Mghir A. (2009): Panton–Valentine leukocidin enhances the severity of community-associated methicillin-resistant Staphylococcus aureus rabbit osteomyelitis. *PloS one*, 4, e7204.

43-Skov, R., R. Smyth, M. Clausen, A. Larsen, N. Frimodt-Møller, B. Olsson-Liljequist and Kahlmeter G. (2003): Evaluation of a cefoxitin 30 µg disc on Iso-Sensitest agar for detection of methicillin-resistant Staphylococcus aureus. *Journal of Antimicrobial Chemotherapy*, 52, 204-207.

44-Felten, A., B. Grandry, P. H. Lagrange and I. Casin (2002): Evaluation of three techniques for detection of low-level methicillin-resistant Staphylococcus aureus (MRSA): a disk diffusion method with cefoxitin and moxalactam, the Vitek 2 system, and the MRSA- screen latex agglutination test. *Journal of clinical microbiology*, 40, 2766-2771.

45-Smyth, R. and G. Kahlmeter, (2005): Mannitol salt agar-cefoxitin combination as a screening medium for methicillin-resistant Staphylococcus aureus. *Journal of clinicalmicrobiology*, 43.3799-3797.

46-Noguchi, N., J. Suwa, K. Narui, M. Sasatsu, T. Ito, K. Hiramatsu and Song J.-H. (2005): Susceptibilities to antiseptic agents and distribution of antiseptic-resistance genes qacA/B and smr of methicillin-resistant Staphylococcus aureus isolated in Asia during 1998 and 1999. *Journal of medical microbiology*, 54, 557-565.

48-Abulreesh, H. H., S. R. Organji, G. E. H. Osman, K. Elbanna, M. H. K. Almalki and Ahmad I. (2017): Prevalence of antibiotic resistance and virulence factors encoding genes in clinical Staphylococcus aureus isolates in Saudi Arabia. *ClinicalEpidemiology and Global Health*, 5, 196-202.

47-Taghaddosi, R., A. Gholipour, M. Zeraatpisheh, M. Safarpour-Dehkordi, D. Darban-Sarokhalil and Heibati-Goujani F. (2016): A frequency and molecular typing study of methicillin- resistant staphylococcus aureus isolates in teaching hospitals in Shahrekord, southwestern Iran. *Jundishapur Journal of Microbiology*, 10, 1-7.

49-Goyal, R., S. Das and Mathur M. (2002): Colonisation of methicillin resistant Staphylococcus aureus among health care workers in a tertiary care hospital of Delhi. *Indian journal of medical sciences*, 56, 321-324.

50-Horner, C., L. Utsi, L. Coole and Denton M. (2017): Epidemiology and microbiological characterization of clinical isolates of Staphylococcus aureus in a single healthcare region of the UK, 2015. *Epidemiology & Infection*, 145, 386-396.

51-Ahmad, S. (2010): Prevalence of Staphylococcus aureus colonization among healthcare workers at a specialist hospital in Saudi Arabia. *Journal of clinical and diagnostic research : JCDR*, 4, 2438-2441.

52-Pan, A., A. Lee, B. Cooper, A. Chalfine, G. Daikos, S. Garilli, H. Goossens, S. Malhotra-Kumar, J. Martínez and Patroni A. (2013): Risk factors for previously unknown meticillin- resistant Staphylococcus aureus carriage on admission to 13 surgical wards in Europe.*Journal of Hospital Infection*, 83, 107-113.

53-Fadeyi, A., B. Bolaji, O. Oyedepo, O. Adesiyun, M. Adeboye and Olanrewaju T. (2010): Methicilin resistant Staphylococcus aureus carriage amongst healthcare workers of the critical care units in a Nigerian hospital. *Am J Infect Dis*, 6, 18-23.

54-Pathare, N. A., H. Asogan, S. Tejani, G. Al Mahruqi, S. Al Fakhri, R. Zafarulla and Pathare A. V. (2016): Prevalence of methicillin resistant Staphylococcus aureus [MRSA] colonization or carriage among health-care workers. *Journal of infection and public health*, 9, 571- 576.

55-Khairalla, A. S., R. Wasfi and Ashour H. M. (2017): Carriage frequency, phenotypic, and genotypic characteristics of methicillin-resistant Staphylococcus aureus isolated from dental health-care personnel, patients, and environment. *Scientific reports*, 7, 7390.

56-Islam, T. A. B. and Shamsuzzaman S. (2015): Prevalence and antimicrobial susceptibility pattern of methicillin-resistant, vancomycin-resistant, and Panton-Valentine leukocidin positive Staphylococcus aureus in a tertiary care hospital Dhaka, Bangladesh. *Tzu Chi Medical Journal*, 27, 10-14.

57-Mesrati, I., M. Saidani, S .Ennigrou, B. Zouari and Redjeb S. B.(2010): Clinical isolates of Panton–Valentine leucocidin-and γ-haemolysin-producing Staphylococcus aureus: prevalence and association with clinical infections. *Journal of Hospital Infection*, 75, 265-268.

58-Sobhy, N., ., F. Aly, ., O. El Kader, .a Abd, A. Ghazal, . and Elbaradei A. (2012): Community- acquired methicillin-resistant Staphylococcus aureus from skin and soft tissue infections (in a sample of Egyptian

population): analysis of mec gene and staphylococcal cassette chromosome. *Brazilian Journal of Infectious Diseases*, 16,426-431.

59-Huang, Y.-C. and C.-J. Chen (2011): Community-associated meticillin-resistant Staphylococcus aureus in children in Taiwan, 2000s. *International journal of antimicrobial agents*, 38, 2-8.

60-Cirkovic, I., S. Stepanovic, R. Skov, J. Trajkovic, A. Grgurevic and Larsen A. R. (2015): Carriage and genetic diversity of methicillin-resistant Staphylococcus aureus among patients and healthcare workers in a Serbian university hospital. *PloS one*, 10, e0127347.

61-Naz, H., F. Çevik and Aykin N. (2006): Nasal Staphylococcus aureus carriage among hospitalstaff in Eskisehir Yunus Emre state hospital. *ANKEM Dergisi*, 20, 141-144.

62-Dulon, M., F. Haamann, C. Peters, A. Schablon and Nienhaus A. (2011): MRSA prevalence in European healthcare settings: a review. *BMC infectious diseases*, 11, 13.8.

63-Dulon, M., C. Peters, A. Schablon and Nienhaus A. (2014): MRSA carriage among healthcare workers in non-outbreak settings in Europe and the United States: a systematic review. *BMC infectious diseases*, 14, 363.

64-Isaacs, D., A. Daley, D. Dalton, R. Hardiman and Nallusamy R. (1998): Swabbing computers in search of nosocomial bacteria. *The Pediatric infectious disease journal*, 17, 533.

65-Rusin, P., S. Maxwell and Gerba C. (2002): Comparative surface-to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage. *Journal of Applied Microbiology*, 93, 585-592.

66-Singh, V., V. Aggarwal, S. Bansal, S. Garg and Chowdhary N. (1998): Telephone mouthpiece as a possible source of hospital infection. *The Journal of the Association of Physicians of India*, 46, 372-373.

67-Uneke, C., A. Ogbonna, P. Oyibo and Ekuma U. (2009): Bacteriological assessment of stethoscopes used by medical students in Nigeria: implications for nosocomial infection control. *Healthcare Quarterly*, 12.

68-Castro, A., N. Komora, V. Ferreira, A. Lira, M. Mota, J. Silva and Teixeira P. (2016): Prevalenceof Staphylococcus aureus from nares and hands on health care professionals in a Portuguese Hospital. *J Appl Microbiol*, 121, 831-839.

69-Shi, G.-s., ., M. Boost, . and Cho P. (2015): Prevalence of antiseptic-resistance genes in staphylococci isolated from orthokeratology lens and spectacle wearers in Hong Kong. *Investigative ophthalmology & visual science*, 56, 3069-3074.

70-Chaka, T., G. Misgana, B. Feye and Kassa R. (2016): Bacterial isolates from cell phones and hands of health care workers: A cross sectional study in pediatric wards at Black Lion Hospital, Addis Ababa, Ethiopia. *J Bacteriol Parasitol*, 7, 2.

71-Iyer, A., T. Kumosani, E. Azhar, E. Barbour and Harakeh S. (2014): High incidence rate of methicillin-resistant Staphylococcus aureus (MRSA) among healthcare workers in Saudi Arabia. *The Journal of Infection in Developing Countries*, 8, 372-378.

72-Ulger, F., S. Esen, A. Dilek, K. Yanik, M. Gunaydin and Leblebicioglu H. (2009): Are we aware how contaminated our mobile phones with nosocomial pathogens? *Annals of clinical microbiology and antimicrobials*, 8, 7.

73-Elkholy, MOHAMAD T, E. and . IBRAHEM E. (2010): Mobile (cellular) phone contamination with nosocomial pathogens in Intensive care units. *Med J Cairo Univ*, 78, 1-5.

74-Oguzkaya-Artan, M., Z. Baykan, C. Artan and Avsarogullari L. (2015): Prevalence and risk factors for methicillin resistant Staphylococcus aureus carriage among emergency department workers and bacterial contamination on touch surfaces in Erciyes University Hospital, Kayseri, Turkey. *African health sciences*, 15, 1289-1294.

75-Morubagal, R. R., S. G. Shivappa, R. P. Mahale and Neelambike S. M. (2017): Study of bacterial flora associated with mobile phones of healthcare workers and non-healthcare workers. *Iranian journal of microbiology*, 9, 143.

76-Misgana, G. M ,.K. Abdissa and Abebe G. (2015): Bacterial contamination of mobile phones of health care workers at Jimma University Specialized Hospital, Jimma, South West Ethiopia. *International journal of infection control*, 11.

77-Wilson, A. P., S. Hayman, T. Whitehouse, J. Cepeda, C. Kibbler, S. Shaw, C. Zelaya, B. Cookson, M. Singer and Bellingan G. (2007): Importance of the environment for patient acquisition of methicillin-resistant Staphylococcus aureus in the intensive care unit: a baseline study. *Critical care medicine*, 35, 2275-2279.