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The relationship between hand hygiene practices and nasal *Staphylococcus aureus* carriage in healthcare workers

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Key words: *Staphylococcus aureus;* nasal carriage; hand hygiene practices

Parole chiave: *Staphylococcus aureus*; carica batterica nelle cavità nasali; igiene delle mani

Summary

Background: *The nasal carriage rate of* Staphylococcus aureus *in healthcare workers (HCWs) is higher than the general population. Their hands serve as vectors for transmitting S.aureus colonized in the nose to patients.* **Objectives**: *To determine the rate of nasal S.aureus carriage and methicillin resistance in HCWs and to evaluate the relationship between carriage and personal risk factors and hand hygiene behaviors.* **Methods:** *The questionnaire included questions about sociodemographic characteristics, occupational and personal risk factors for S.aureus carriage, the "Hand Hygiene Belief Scale (HHBS)," and "Hand Hygiene Practices Inventory (HHPI)". Nasal culture was taken from all participants. Presence of S.aureus, methicillin and mupirocin resistance were investigated in samples.* **Results:** *The study was carried out with 269 HCWs. The prevalence of S.aureus carriage was 20.1% (n:54). Among 54 S.aureus carriers, only one person had MRSA (0.37%). All S.aureus isolates were susceptible to mupirocin. S.aureus carriage was found to be significantly lower in the smoker group (p:0.015) and in the personnel wearing gloves during the procedures of each patient (p:0.002). S.aureus culture positivity was found to decrease significantly with increasing handwashing frequency (p:0.003). The mean HHPI score was higher in women (p:0.001). The mean HHPI score was lower in the group with nasal carriers than in non-carriers (p:0.176).* **Conclusion:** *The knowledge of hand hygiene practices, high frequency of handwashing, and wearing different gloves during the procedure of each patient decrease S.aureus nasal carriage in HCWs. In addition mupirocin is still effective in nasal S.aureus carriers.*

Riassunto

***«La relazione tra l'igiene delle mani e la trasmissione di* Staphylococcus aureus *nasale nel personale sanitario»*.**
Introduzione: *La carica batterica di* Staphylococcus aureus *nelle cavità nasali è più alta nel personale sanitario rispetto alla popolazione generale. Le mani del personale sanitario fungono da vettore per la trasmissione ai pazienti dello S. aureus.* **Obiettivi:** *Determinare l'incidenza della presenza di S. aureus nasale e della resistenza a meticillina nel personale sanitario e valutare la relazione tra carica batterica e fattori di rischio personali e comportamento corretto di igiene delle mani.* **Metodi:** *È stato somministrato un questionario comprendente domande su caratteristiche sociodemografiche, fattori di rischio occupazionali e personali per la presenza di S. aureus, il Questionario sulla percezione dell'igiene delle mani (HHBS) e le Procedure nell'igiene delle mani (HHPI). Una coltura nasale è stata ottenuta per ciascun partecipante allo studio. La presenza di S. aureus e l'eventuale resistenza a meticillina e mupirocina sono state indagate sui campioni raccolti.* **Risultati:** *Lo studio è stato condotto su 269 operatori sanitari. La*

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prevalenza di S. aureus è stata del 20.1% (n:54). Su 54 portatori di S. aureus, solo una persona presentava resistenza a meticillina (0.37%). Tutti gli isolati di S. aureus sono risultati sensibili alla mupirocina. La presenza di S.aureus era significativamente inferiore tra i fumatori (p:0.015) e nel personale che indossava guanti protettivi per trattare ciascun paziente (p:0.002). La positività delle colture di S. aureus era tanto più bassa quanto più alta era la frequenza del lavaggio delle mani (p:0.003). Lo score medio che valuta le procedure di igiene delle mani (HHPI) è risultato più alto tra le donne (p:0.001) e più basso nel gruppo portatore di S. aureus rispetto ai non portatori (p:0.176).

Introduction

Staphylococcus aureus is a member of transient or permanent flora in many human body regions, especially skin and mucosa (38). *S.aureus* is a causative agent in approximately 5% of healthcare-associated infections (HCAIs) in Turkey. It is responsible for 11.4% of surgical site infections, 8.1% of bloodstream infections, and approximately 5% of pneumonia related to healthcare. Methicillin resistance and multiple antibiotic resistance are observed in 55-59% of *S.aureus* isolated from these infections (20).

Although *S.aureus* carriage is most commonly detected in the nose, carrier status may occur in the skin, perineum, pharynx and rarely in the vagina, axilla and gastrointestinal system (4, 41). The rate of nasal carriage in healthcare workers (HCWs) is higher than the general population (16). Many outbreaks of HCAIs have been reported in HCWs, who are asymptomatic nasal carriers (17, 29). In order to reduce the frequency of HCAIs caused by *S.aureus* and especially methicillin-resistant *S.aureus* (MRSA), the identification and treatment of *S.aureus* nasal carriers appear to be one of the most critical steps of the infection control methods.

HCWs' hands play an important role in the transmission of an infectious microorganism to the patient. Hand hygiene has a vital role in infection control, and in many studies, the rate of handwashing of HCWs, especially of physicians, was reported to be lower than expected (8). Hands serve as vectors for transmitting *S.aureus* colonized in the nose to patients (23). For these reasons, it is important to investigate whether there is a relationship between hand hygiene behaviors and nasal carriage of *S.aureus*, especially in HCWs. Although handwashing behavior is affected by many factors, workload, handwashing habits, difficulty in accessing hand hygiene products, low belief in hand hygiene, lack of role models, being a physician, and lack of knowledge are the main factors affecting hand hygiene compliance (2, 23).

The aim of this study was to determine the rate of nasal *S.aureus* carriage in HCWs working in intensive care units, operating rooms, and various units in our hospital. We also aimed to investigate the methicillin resistance rates and to evaluate the relationship between *S.aureus* carriage and occupational and personal risk factors and hand hygiene behaviors.

Methods

Study design

This cross-sectional study was conducted between August and September 2019 among physicians, nurses, and cleaning staff working at Evliya Celebi Training and Research Hospital in Kutahya, Turkey. Local ethics committee approval and administrative permissions were obtained. The sample size was calculated as 271 with a 90% confidence interval, 3% of error margin, and an expected prevalence of 10% (the prevalence of *S.aureus* carriage in hospital staff varies between 3% and 17% according to the literature). Exclusion criteria were as follows: being a staff member in any of the polyclinics, having upper respiratory tract infection, having used antibiotics in the last three weeks, having skin infections (impetigo, soft tissue infection), atopic dermatitis, and immunodeficiencies, and having undergone surgery or nose lesions in the last six months. A total of 300 people were reached; however, those who did not answer more than 50% of the questionnaire questions and those who met the exclusion criteria were excluded from the study. As a result, a total of 269 people were included in the study.

Survey

The participants were informed about the study, and the questionnaire was conducted with the face-to-face interview method. The questionnaire included questions inquiring participants' sociodemographic characteristics, questions about occupational and personal risk factors for *S.aureus* carriage, the "Hand Hygiene Belief Scale (HHBS)," and "Hand Hygiene Practices Inventory (HHPI). HHBS and HHPI were developed by Thea van de Mortel in 2009 (42). In 2016, Karadag et al. tested the validity and reliability of the Turkish versions of HHBS and HHPI. Coefficients of the internal consistency reliability were 0.76 and 0.85, respectively (25). In order to use the scales in the study, permission was obtained from M. Karadag. HHBS is scored as 1=strongly disagree, 2=disagree, 3=not sure, 4=agree, 5=strongly agree, and HHPI is scored as; 1=never, 2=sometimes, 3=often, 4=most of the time, 5=always. Total scores range from 22 to 110 for HHBS and 14 to 70 for HHPI. High scores indicate that hand hygiene practices are always performed.

Sample collection, laboratory analysis

Sterile cotton swabs with transport media (BTR, Gul-Ka, Ankara, Turkey) were used to collect the nasal culture sample from the participants. Samples were obtained by gently rotating the sticks five times in both nasal osteomas and sent to the microbiology laboratory within 30 minutes. Samples were cultured on a selective medium mannitol salts agar medium (RTA, Kocaeli, Turkey) and, after 48 hours incubation at 35-37^{0}C, mannitol positive colonies were transferred to blood agar (RTA, Kocaeli, Turkey) for conventional methods (catalase, tube coagulase, etc.). Catalase and coagulase-positive isolates were identified by automated bacteria identification device (Phoenix, BD, USA). Disc diffusion test method was used to investigate methicillin resistance with 30 µg cefoxitin disc (Bioanalyse, Ankara, Turkey) according to EUCAST criteria (39) and high-level mupirocin resistance with 200 µg antibiotic disc (Bioanalyse, Ankara, Turkey) according to CLSI criteria (9). Cefoxitin MIK gradient test (Biomerieux, France) was studied for the confirmation of methicillin-resistant isolates. The isolates with cefoxitin MIK>4 mg/l were accepted as MRSA (39).

Statistical analysis

SPSS package program was used in the evaluation of the data. Statistical analyses were performed using the Kolmogorov-Smirnov test for the normality test of the data. In the comparison of the averages, Student's t-test was used for the normally distributed-matched data. X^2 test was used for the analysis of categorical variables. The level of significance was set at $p < 0.05$.

Results

The study was carried out with the inclusion of 269 people (64.3%, n: 173 women and 35.7% n: 96 men) and the mean age was 33.28±8.25 (min: 19, max: 59). The prevalence of *S.aureus* carriage was 20.1% (n: 54). Among 54 *S.aureus* carriers, only one person (a female nurse working in operating room) had MRSA (0.37%). All *S.aureus* isolates were susceptible to mupirocin.

There was no statistically significant relationship between culture results and age, sex, job, education level, hospital unit, tenure, presence of chronic disease (diabetes mellitus, hypertension, asthma, chronic lung disease, heart failure, kidney failure, etc.), and having a child and pets at home (table 1).

No statistically significant relationship was found between culture results and both the frequency of nose cleaning and hand disinfectant use. However, *S.aureus* carriage was found to be significantly lower in the smoker group and in the personnel wearing gloves during the procedures of each patient. *S.aureus* culture positivity was found to decrease significantly with increasing handwashing frequency (table 2).

When the HHPI-HHBS scores of the HCWs were evaluated, the mean HHPI score was 64.45±7.35, while the mean HHBS score was 84.69±9.52. The mean HHPI score was lower in the group with nasal carriers than in non-carriers. There was no statistically significant relationship between HHBS score and culture results (table 3).

Table 1 - Comparison of sociodemographic characteristics and culture results of the study group

	S.aureus culture results			
	Negative (N:215) n (%)	Positive (N:54) n (%)	Total (N:269) n (%)	Statistics
Age				
Mean±SD	33.4±8.42	32.4±7.54	33.28±8.25	t: 0.820 p:0.413
Sex				
Male	74 (77.1)	22 (22.9)	96 (35.7)	X^2: 0.752
Female	141 (81.5)	32 (18.5)	173 (64.3)	p:0.386
Education level				
High school/University	50 (79.4)	13 (20.6)	63 (23.4)	X^2:0.016
Below	165 (80.1)	41 (19.9)	206 (76.6)	p:0.899
Hospital unite				
Service	87 (79.8)	22 (20.2)	109 (40.5)	X^2: 0.424
Operating room	49 (77.8)	14 (22.2)	63 (23.5)	p:0.935
Intensive care	60 (82.2)	13 (17.8)	73 (27.1)	
Multiple unit	19 (79.2)	5 (20.8)	24 (8.9)	
Job				
Doctor	41 (70.7)	17 (29.3)	58 (21.6)	X^2: 3.980
Nurse	138 (82.1)	30 (17.9)	168 (62.4)	p:0.136
Cleaning staff	36 (83.7)	7 (16.3)	43 (16.0)	
Tenur				
Less than 1 year	26 (78.8)	7 (21.2)	33 (12.3)	X^2: 0.115
1-5 years	80 (79.2)	21 (20.8)	101 (37.5)	p:0.944
More than 5 years	109 (80.7)	26 (19.3)	135 (50.2)	
Pets at home				
Yes	186 (80.9)	44 (19.1)	230 (85.5)	X^2: 0.881
No	29 (74.4)	10 (25.6)	39 (14.5)	p:0.348
Child at home				
Yes	104 (78.2)	29 (21.8)	133 (49.4)	X^2: 0.491
No	111 (81.6)	25 (18.4)	136 (50.6)	p:0.480
Chronic disease				
Yes	195 (80.6)	47 (19.4)	242 (89.9)	X^2: 0.640
No	20 (74.1)	7 (25.9)	27 (10.1)	p:0.424

The mean HHPI score was 62.95±6.65 in men, 65.25±7.12 in women. Therefore, the mean score was higher in women (t: 2.491, p: 0.001). There was no statistically significant relationship between HHBS scores and sex (table 4).

When evaluating *S.aureus* carriers according to sex, the HHPI score was 61.09±8.92 in males and 61.03±9.06 in females (t: 0.024, p: 0.981). Also, the HHBS score was 86.69±11.70 in males and 81.75±11.39 in females (t: 1.546, p: 0.128). There was no statistically significant difference.

Table 2 - Comparison of culture results and some hygiene habits

	S.aureus culture results			
	Negative (N:215) n (%)	Positive (N:54) n (%)	Total* (N:269) n (%)	Statistics
Nose cleaning frequency				
Sometimes	60 (78.9)	16 (21.1)	76 (28.3)	X^2: 0.063
Everyday	155 (80.3)	38 (19.7)	193 (71.7)	p:0.802
Frequency of wearing gloves				
Not used	7 (46.7)	8 (53.3)	15 (5.6)	X^2: 12.55
When it is necessary	82 (78.1)	23 (21.9)	105 (39.0)	**p:0.002**
For each patient	126 (84.6)	23 (15.4)	149 (55.4)	
Using hand disinfectant				
No	46 (78.0)	13 (22.0)	59 (21.9)	X^2: 0.181
Yes	169 (80.5)	41 (19.5)	210 (78.1)	p:0.671
Smoking				
No	129 (75.4)	42 (24.6)	171 (63.6)	X^2: 5.89
Yes	86 (87.8)	12 (12.2)	98 (36.4)	**p:0.015**
Daily hand washing frequency				
5 times	19 (63.3)	11 (36.7)	30 (11.2)	X^2: 11.484
5-10 times	25 (67.6)	12 (32.4)	37 (13.7)	**p:0.003**
>10 times	171 (84.7)	31 (15.3)	202 (75.1)	

* Percentage of column

Table 3 - Comparison of culture results and HHPI-HHBS scores

	S.aureus culture results			
	Negative (N:215) n (%)	Positive (N:54) n (%)	Total (N:269) n (%)	Statistics
HHPI				
Mean±SD	65.30±6.70	61.05±8.92	64.45±7.35	t: 0.387
(Min-Max)	(40-70)	(31-70)	(31-70)	**p:0.001**
HHBS				
Mean±SD	84.93±8.91	83.75±11.06	84.69±9.52	t: 0.807
(Min-Max)	(50-110)	(29-110)	(29-110)	p:0.420

Abbreviations: HHBS: Hand Hygiene Belief Scale, HHPI: Hand Hygiene Practices Inventory

Table 4 - Comparison of HHPI-HHBS scores of the study group by sex

	Male	Female	Total	Statistics
HHPI				
Mean±SD	62.95±6.63	65.25±7.12	64.45±7.35	t: 2.491
(Min-Max)	(38-70)	(31-70)	(31-70)	**p:0.001**
HHBS				
Mean±SD	85.75±9.91	84.10±9.20	84.69±9.52	t: 1.356
(Min-Max)	(54-110)	(29-110)	(29-110)	p:0.176

Abbreviations: HHBS: Hand Hygiene Belief Scale, HHPI: Hand Hygiene Practices Inventory

Discussion

The prevalence of HCAIs is between 5.7% and 19.1% in developing countries (44). *S.aureus* infections are responsible for 5% of HCAIs in our country. Methicillin resistance is found in 55-59% of *S.aureus* isolated from healthcare-associated pneumonia, urinary tract infection, bloodstream infection, and surgical site infections (20).

The fact that HCWs are nasal carriers of *S.aureus* and the lack of appropriate handwashing habits make it easier to spread this bacterium to patients (36). In a rewiev of Hawkins et al., it was reported that persistent carriers and HCWs with skin lesions were responsible for MRSA outbreaks. Detection and decolonization of carriage in HCWs in hospitals with endemic and non-endemic MRSA infections reduces the incidence of MRSA infection (19). In an opposite study that screened patients and staff to determine the source it was reported HCWs were rarely responsible for the outbreaks (40). A meta-analysis of 22 current studies on the risk of occupational infection risks and HCWs who are carriers of multiple drug resistant organisms refers to the limitations of the research, such as inadequate number of participants, not including an appropriate comparison group, not explaining the questionnaire in detail, and not presenting the results clearly. In addition, it is reported that the screening of health personnel and patients at the same time is important (35). For the prevention of HCAIs, the main measures to be taken are the detection and appropriate treatment of HCWs with nasal carriage and increasing hand hygiene compliance. In our study, the prevalence of nasal *S.aureus* carriage in HCWs was investigated. Additionally, HHBS and HHPI were evaluated by belief in hand hygiene and hand hygiene behaviors.

In our study, the prevalence of nasal *S.aureus* carriage in health workers was determined as 20.1%. Only one person had MRSA (0.37%). Carrier prevalence varies by country, hospital units, number of participants, and demographic characteristics. In a meta-analysis, which included 22 studies, *S.aureus* carriage was found to be 22.7%, and MRSA carriage was 32.8% in Iran (12). A meta-analysis of 127 studies from 37 different countries reported that MRSA carriage ranged from 4.6% to 5.1%. Considering the studies conducted in the last five years, the prevalence of *S.aureus* carriage varies between 11% and 45.4%, while the prevalence of MRSA carriage varies between 1.3% and 25.5% (1, 5, 7, 10, 11, 14, 15, 21, 22, 26, 28, 30, 32, 33, 36, 43). In a study, it was reported that the carriage rate of MRSA except for epidemic conditions was between 0-15%. However, it is stated that prevalence may be higher if carriage is investigated in the period of transient colonization. In this respect, it was emphasized that results of prevalence studies should be interpreted carefully (19). Since our investigation is a point prevalence study, it shows the situation in the time interval when it was performed.

The demographic characteristics of the HCWs included in the studies affect the prevalence of carriage. Recent studies have reported the risk factors for *S.aureus* carriage as being of older age (21), female (6, 21), male (1, 34, 43), and a nurse (1, 11). Risk factors for MRSA carriage include being a nurse (6, 11, 15, 22), being a woman (21, 32), being a male (6), being older than 40-45 years (6, 22), working in the intensive care unit (22), and having diabetes mellitus (30).

In our study, *S.aureus* carriage resulted higher among nurses than in other occupational groups. In our study, no statistically significant relationship was found between culture results and sociodemographic factors such as age, sex, occupation, hospital unit, education level, tenure, presence of chronic disease, and having children and/or pets at home. Since MRSA was detected in only one HCW, no assessment of MRSA carriage could be made.

Different studies have investigated the effects on *S.aureus* carriage in the nose of some risk factors such as the frequency of handwashing, the use of scrubbing during handwashing (30), the use of masks (36), smoking (31, 36, 37), and the presence of smokers and HCWs at home (32). In the study of Legese et al., it was reported that hand scrubbing was a risk factor for MRSA carriage (30). In the study of Oğuzkaya-Artan et al., it was found that the use of masks reduces MRSA carriage (32).

When the relationship between culture results and some habits was evaluated in our study, there was no statistically significant relationship between nasal cleaning frequency and hand disinfectant use. It was found that *S.aureus* culture positivity decreased

with increasing handwashing frequency. This finding emphasizes the importance of proper application of general hand hygiene rules in reducing nasal *S.aureus* carriage, which causes HCAIs. Also, in our study, *S.aureus* carriage was found to be significantly lower in the smoker group and in the HCWs who had the habit of using new gloves for each patient. The use of new gloves for each patient is among the general hygiene practices and may be effective in reducing the carriage of *S.aureus* in the nose. However, we have difficulty explaining the negative relationship between smoking and carriage. We think that the higher frequency of nasal cleansing (p: 0.003) in the smoking group may have affected the culture results.

Mupirocin treatment is still effective in nasal *S.aureus* carriers (31). CLSI recommends the study of high levels of mupirocin resistance with 200 μg antibiotic disc in *S.aureus* (9). In our study, all *S.aureus* isolates were found to be susceptible to mupirocin. High-level mupirocin resistance was investigated in the study of Kavitha et al. and mupirocin resistance was not detected (27). In the study of Kaur et al., mupirocin resistance was found in 0.71% of MRSAs, whereas no resistance was reported in methicillin-sensitive *S.aureus* (26). However, mupirocin susceptibility was studied with different methods and different amounts of antibiotics. Using a 10 μg antibiotic disc, Bucompain et al. found 3.9% resistance in MSSA and no resistance in MRSA (6). Ulug et al. investigated low-level mupirocin resistance using a 5 μg antibiotic disk and found no resistance in both MSSA and MRSA (41).

Hand hygiene is the most important step in reducing HCAIs (8, 18, 44). Hand hygiene compliance in HCWs is between 30 and 40% on average and is very low (2, 8, 13). Being a doctor, being a nursing student, working in intensive care units, being a man, and wearing gloves were reported as the main causes of non-compliance with hand hygiene (8). In order to increase hand hygiene compliance, it is necessary to evaluate handwashing behaviors, routinely monitor them, give feedback, as well as remind necessary information (24). In our study, HHBS and HHPI were used to measure hand hygiene beliefs and behaviors of nursing students (42). These scales were translated into Turkish, applied to nursing students in several studies, and their reliability and validity were proved (3, 25). High scores on both scales indicate that there is a high belief in hand hygiene and hygiene practices are always performed. In our study, the mean HHPI was found to be 64.45±7.35, and it was found to be higher in women than in men. The mean HHBS score was 84.69±9.52 and was similar in both sexes. In the study of Karadağ et al., the mean HHBS score was 85.26±9.11, while the mean HHPI score was 64.90±5.71, with no differences between men and women (25). As far as we know, these two scales have not been applied to doctors, nurses, or different HCWs neither in our country nor in other countries. In addition, our study is the first to investigate the relationship between these two scales and nasal *S.aureus* carriage.

In our study, the mean HHPI score was lower in the *S.aureus* carrier group than the non-carrier group. There was no statistically significant relationship between HHBS scores and culture results. The fact that the HHBS score is not different in the carrier and non-carrier group indicates that hand hygiene belief is established in our hospital. There was no statistically significant difference between men and women in terms of mean HHPI scores and HHBS scores among *S.aureus* carriers. In our opinion, when evaluating the relationship between carriage and HHPI or HHBS, it should be remembered that the time of sample collection for transient colonization and the personal characteristics and responses of the participants are confusing factors.

The first limitation of our study was that we collected only one nasal culture from each HCW. With only one nasal culture, it is difficult to determine whether the carriage is continuous or transient or intermittent. In the study of Garcia et al., continuous *S.aureus* carriage was reported as only 12.5%, and continuous MRSA carriage was 45% (14). The second limitation of our study was that only nasal carriage was investigated and perianal/axilla carriage was not investigated. That choice was taken in order to improve the participation of our worker minimizing the impact of the study procedure.

Another limitation is that the study design is cross-sectional and that because of it being a questionnaire study, memory factors can affect the answers of workers. Also, due to time constraints, it was performed only in the selected sample. .

As a result, in our study, it was determined that the prevalence of *S.aureus* nasal carriage was lower in HCWs who had the habit of frequent hand washing and the habit of using different gloves during each patient's procedure. By raising awareness of hand hygiene practices, it is thought that nasal carriage of *S.aureus*, a pathogen responsible for HCAIs, will reduce in HCWs. However, intervention studies should be conducted in order to show the relationship between the effectiveness of hand hygiene practices and nasal carriage. In our study, only due diligence was performed. In the following periods, it is thought that our results will be guiding for the intervention studies that will be planned about hygiene practices and carriage in health workers in our hospital. After all, mupirocin is still effective in nasal *S.aureus* carriers.

No potential conflict of interest relevant to this article was reported by the authors

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