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Prevalence of Nasal Carriage of *Staphylococcus aureus* and its Antibiotic Susceptibility among Healthcare Workers (HCWs) in Ukraine

Abstract

BACKGROUND. Nasal carriage of *Staphylococcus aureus* among hospital personnel is a common cause of hospital acquired infections. Emergence of drug resistant strains especially methicillin resistant *S. aureus* (MRSA) is a serious problem in hospital environment. Therefore, the aim of this study was to determine the prevalence of nasal carriage of *Staphylococcus aureus* its antibiotic susceptibility among healthcare workers (HCWs) in Ukraine.

METHODS. This cross-sectional study was conducted from January to December 2017. The study included medical workers from 19 hospitals in different Ukrainian regions. Nasal swabs were taken from 755 randomly selected HCWs. The mean age of participants was 32.41 ± 8.29 years (range 19—74 years) with a male-to-female ratio of 0.47. The isolates were identified as *S. aureus* based on morphology, Gram stain, catalase test, coagulase test, and mannitol salt agar fermentation. The sensitivity patterns of S. aureus strains were determined by disk diffusion method (Kirby — Bauer). The panel of antibiotics used in sensitivity tests included: penicillin, oxacillin, cefoxitin, amoxicillin/clavulanic acid, gentamicin, tobramicin, ciprofloxacin, levofloxacin, moxifloxacin, mupirocin, nitrofurantoin, vancomycin, teicoplanin, fosfomycin, clindamycin, erythromycin, rifampicin, linezolid, tetracycline, tigecycline, trimethoprim/sulphamethoxazole, and fusidic acid. Interpretative criteria were those suggested by the CLSI (Clinical and Laboratory Standards Institute). MRSA were confirmed by detection of the *mecA* gene by polymerase chain reaction.

RESULTS. Nasal screening identified 31.1 % (235/755) *S. aureus* carriers. Of the 235 nasal carriers of *S. aureus*, 83.4 % (196/755) carried MSSA (methicillin-sensitive *S. aureus*) and 39/755 (16.6 %) carried MRSA. The frequency of MRSA and MSSA carriage also varied according to the department/ward. The highest prevalence of nasal carriage of MRSA was in the surgical wards. The staff of the general, pediatric, cardiovascular, neuro and orthopedic surgery wards together with the emergency department accounted for 56.4 % of all MRSA carriers. There was no significant difference between the sexes ($p = 0.247$), age ($p = 0.817$), and years of healthcare service ($p = 0.15$) with regard to the nasal carriage of MRSA and MSSA. In univariate analysis we divided the hospital departments into: emergency, internal medicine, pediatrics, ICUs, surgery, and non-medical units and found no significant difference between MSSA and MRSA carriers ($p = 0.224$). In the multivariate analysis, the occupation «nurse» was independently associated with MRSA carriage ($p = 0.012$, odds ratio 3.6, 95 % confidence interval 1.3—9.7). All the *S. aureus* isolates recovered from nasal carriers, were susceptible to linezolid, tigecycline, vancomycin, teicoplanin, and mupirocin. Susceptibility to the other antimicrobials was also on a high level: 98.3 % of strains were found susceptible to trimethoprim/sulphamethoxazole, 96.2 % — to nitrofurantoin, 95.3 % — to fusidic acid, 92.3 % — to fosfomicin, 88.5 % — to amoxicillin/clavulanic acid, 87.2 % — to tobramycin, 86.8 % — to clindamycin. Resistance to oxacyllin came up to 16.6 %.

CONCLUSIONS. Nasal carriage of *S. aureus* appears to play a key role in the epidemiology and pathogenesis of infection. HCWs who are at interface between the hospital and the community may serve as agents of cross contamination of hospital acquired and community acquired MRSA. It is of importance to follow the evolution of resistance to antibiotics in this species, especially to β-lactams.

KEY WORDS: *Staphylococcus aureus*, nasal carriage, healthcare workers (HCWs), antimicrobial susceptibility, MRSA, Ukraine.

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INTRODUCTION

Staphylococcus aureus has been recognized as an epidemiologically important pathogen [1—4]. *S. aureus* is a major cause of both nosocomial and community-acquired infections. Despite antibiotic therapy, staphylococcal infections occur frequently in hospitalized patients and have severe consequences [1, 2]. About 35—40 % of patients undergoing surgery acquire at least one nosocomial *S. aureus* infection [3], leading to increased morbidity, mortality, hospital stay, and costs [5].

S. aureus is an opportunistic microorganism and can cause severe infection. Its oxacillin-resistant form (meticillin-resistant *S. aureus*, MRSA) has been the most important cause of antimicrobial resistant healthcare-associated infections worldwide [1, 2]. Over the past decades, the incidence of MRSA in surgical site infections, bloodstream infections, and pneumonia has increased significantly [6, 7]. MRSA is the most commonly identified antimicrobial-resistant pathogen in hospitals in many parts of the world [1—4, 8, 9].

MRSA strains are highly prevalent in Ukrainian hospitals, those strains account for approximately 50 % of all *S. aureus* isolates recovered from health care infections [3, 4, 10]. In Europe, the proportion of MRSA isolates in infected patients varied in 2015 from less than 0 % to more than 57.2 %, with a pooled mean rate of around 16.8 %. [2]. In the United States, the proportion of methicillin resistance in *S. aureus* strains approached almost 60 % in 2003, with an average rate of resistance over the period 1998—2002 of around 50 % [8]. In 2007, a Mediterranean study found that the highest proportions of MRSA were reported by Egypt (52 %), Cyprus (55 %), Algeria (45 %), Malta (50 %) and Jordan (56 %), in comparison to other Mediterranean countries such as Lebanon (12 %), Tunisia (18 %) and Morocco (19 %) [9].

MRSA strains are considered to be endemic in many hospitals throughout the world and are now responsible for approximately 40—60 % of healthcare-associated infections [10, 11]. Compared to methicillin-sensitive *S. aureus* (MSSA), various studies have revealed that infection due to MRSA is associated with significant morbidity, mortality, length of hospital stay, and medical costs [12]. For example, the rate of death due to MRSA (11.8 %) was considerably higher than that due to MSSA (5.1 %) [13].

S. aureus is both a commensal bacterium and a human pathogen. *S. aureus* colonizes various niches of the human body, but the primary colonization site is the anterior nares. The anterior nares are the main reservoir of MRSA, although other body sites are frequently colonised, such as the hands, skin, axillae, and intestinal tract [14, 15]. Approximately 30 % of the human population is colonized with *S. aureus* [16]. It is estimated that 20—30 % of individuals are persistent carriers of *S. aureus*, around 30 % are intermittent carriers, and 40—50 % are noncarriers [17]. Nasal carriage among healthcare workers (HCWs) is the main source for the transmission of MRSA and most *S. aureus* among patients within and between wards [18]. MRSA carriers create major problems for critically ill patients (e.g., intensive care unit (ICU) patients.

Nasal carriage of *S. aureus* among hospital personnel is a common cause of hospital acquired infections. Approximately 5 % of colonised HCWs develop clinical infections [15] and symptomatic MRSA infections among HCWs have been described in several case reports [19]. Emergence of drug resistant strains especially MRSA is a serious problem in hospital environment.

Since it is well known that *S. aureus* can be found as part of the nasal microbiota without causing overt disease, this carrier state may also be an important factor for dissemination from physicians and nurses to patients and vice-versa [20]. Despite the possible role that HCWs may perform in dissemination of MSSA and MRSA strains, relatively few reports have addressed this issue. Knowledge of the prevalence of MRSA and its antimicrobial profile is necessary for selection of the appropriate empirical antimicrobial treatment for *S. aureus* infections [5]. In particular, screening for and eradication of MRSA from colonized HCWs have been recognized and recommended as an important part of a comprehensive infection control policy for this organism. Screening of HCWs for early and rapid identification of MRSA carriage is recommended for reducing the spread of MRSA within hospitals [21].

Objective — to determine the prevalence of nasal carriage of *Staphylococcus aureus* its antibiotic susceptibility among health care workers in Ukraine.

MATERIALS AND METHODS

Setting and design

The study included medical workers from 19 hospitals in different Ukrainian regions. Nasal swabs were taken from 755 randomly selected healthcare workers (doctors, nurses and other health care workers). From January to December 2017, participants were recruited on a voluntary basis during their regular activities. Medical students were excluded from the study. An informed consent form was made available to each participant who also completed a questionnaire regarding demographic data (sex, age and specialty as appropriate). Exclusion criteria for the population under study were the current presence of diseases compatible with *S. aureus* infections such as impetigo, skin and soft tissue infections, sinusitis, otitis or rhinitis, or antibiotic use within the previous three months.

Microbiological methods

Specimens were taken from the subjects in the following way: a sterile moistened swab was inserted into each nostril in turn, to a depth of approximately 1 cm, and rotated five times [23]. For each specimen, both nostrils were sampled using the same swab. The swabs were immediately transported to the microbiology laboratory for further processing. Specimens were inoculated onto Blood agar and incubated overnight at 37 °C for 24 h. The isolates were identified as *S. aureus* based on morphology, Gram stain, catalase test, coagulase test, and mannitol salt agar fermentation. MSSA strains were differentiated from MRSA using agar screen plates (Mueller — Hinton agar) containing 2 μg/ml oxacillin with 4 % NaCl. Isolates with growths on the plates with 2 μg/ml of oxacillin were considered as a MRSA, while isolates that did not grow in the antibiotic-containing medium were considered as MSSA.

Antibiotic susceptibility determination

The sensitivity patterns of S. aureus strains were determined by disk diffusion method (Kirby — Bauer). The panel of antibiotics used in sensitivity tests included: penicillin, oxacillin, cefoxitin, amoxicillin/clavulanic acid, gentamicin, tobramicin, ciprofloxacin, levofloxacin, moxifloxacin, mupirocin, nitrofurantoin, vancomycin, teicoplanin, fosfomycin, clindamycin, erythromycin, rifampicin, linezolid, tetracycline, tigecycline, *trimethoprim/sulphamethoxazole*, and fusidic acid (Himedia, India). Interpretative criteria were those suggested by the CLSI (Clinical and Laboratory Standards Institute) [22]. MRSA were confirmed by detection of the *mecA* gene by PCR (polymerase chain reaction). To analyze sensitivity patterns of MRSA strains more precisely, minimum inhibitory concentration (MIC) of methicillin (oxacillin) were determined by the E-test method (AB Biodisk, Sweden). The isolates were incubated overnight, following which the sensitivity breakpoints for MIC were determined. The sensitivity breakpoints for MIC and the antibiotic disk diffusion method were interpreted according to the manufacturer's instructions (AB Biodisk, Sweden) and the BSAC (British Society for Antimicrobial Chemotherapy) guidelines, respectively [23].

Statistical analysis

Data obtained were transferred for further analysis into computer software WHONET 5.1 (© 1989—2001, World Health Organization. All rights reserved. Freeware downloadable from http://www.who.int/drugresistance/whonetsoftware/en/). The analysis of statistical data was performed using Microsoft Excel. Personal IBM-computer, running Microsoft Windows, was used during the study. The odds ratios (OR), 95 % confidence interval (CI), and p-value were calculated. P-value for the variables analyzed in each case were calculated by the Fisher exact test and the Chi square test. Value of $p < 0.05$ were considered statistically significant.

Ethical considerations

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

Table 1
Prevalence of nasal carriage of methicillin-sensitive and methicillin-resistant *Staphylococcus aureus* among healthcare workers at Ukrainian hospitals by ward ($p < 0.05$)

Department / Ward	Number of samples	Number of nasal carriage	Nasal carriers	
			MSSA	MRSA
Cardiac Surgery	31	11 (35.5 %)	6 (54.5 %)	5 (45.5 %)
Neurosurgery	36	12 (33.3 %)	11 (91.7 %)	1 (8.3 %)
Pediatric Surgery	16	5 (31.2 %)	3 (60.0 %)	2 (40.0 %)
General Surgery	31	17 (54.8 %)	11 (64.7 %)	6 (35.3 %)
Vascular Surgery	26	8 (30.8 %)	6 (75.0 %)	2 (25.0 %)
Emergency department	18	7 (38.9 %)	4 (57.1 %)	3 (42.9 %)
Orthopedic	18	5 (27.8 %)	2 (40.0 %)	3 (60.0 %)
ICU	48	15 (31.2 %)	9 (60.0 %)	6 (40.0 %)
Otorhinolaryngology	19	8 (42.1 %)	6 (75.0 %)	2 (25.0 %)
Urology	16	5 (31.2 %)	5 (100.0 %)	0
Neurology	22	5 (22.7 %)	5 (100.0 %)	0
Haematology	26	6 (23.1 %)	6 (100.0 %)	0
Internal Medicine	35	11 (31.4 %)	6 (54.5 %)	3 (27.3 %)
Peadiatric	156	52 (33.3 %)	50 (96.2 %)	2 (3.8 %)
Laboratory	148	31 (20.9 %)	31 (100.0 %)	0
Radiodiagnostics	83	30 (36.1 %)	27 (90.0 %)	3 (10.0 %)
Office personnel	26	7 (26.9 %)	6 (85.7 %)	1 (14.3 %)
Total	755	235 (31.1 %)	196 (83.4 %)	39 (16.6 %)

Note. MSSA — methicillin-sensitive *Staphylococcus aureus*; MRSA — methicillin-resistant *Staphylococcus aureus*.

RESULTS

During the study period, 755 of all HCWs at the studied Ukrainian hospitals were screened for *S. aureus* carriage. The mean age of participants was 32.41 ± 8.29 years (range 19—74 years) with a male-to-female ratio of 0.47. Nasal screening identified 31.1 % (235/755) *S. aureus* carriers. Of the 235 nasal carriers of *S. aureus*, 83.4 % (196/755) carried MSSA and 39/755 (16.6 %) carried MRSA.

The frequency of MRSA and MSSA carriage also varied according to the department/ward (Table 1). The highest prevalence of nasal carriage of MRSA was in the surgical wards. The staff of the general, pediatric, cardiovascular, neuro and orthopedic surgery wards together with the emergency department accounted for 56.4 % of all MRSA carriers. In univariate analysis we divided the hospital departments into: emergency, internal medicine, pediatrics, intensive care unit (ICU), surgery, and non-medical (laboratory, offis personnel, and paramedical staff) units and found no significant difference between MSSA and MRSA carriers ($p = 0.224$).

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

The other variables studied were occupation (nurse, auxiliary nurse, and non-medical personnel) of HCWs. There was a significant difference between nasal carriage of MRSA and MSSA ($p = 0.032$) with regard to occupation.

In the multivariate analysis, the only significant independent risk factor for nasal carriage of MRSA versus MSSA was the occupation «nurse» (odds ratio 3.6, 95 % confidence interval 1.3—9.7; $p = 0.012$).

The sensitivity of *S. aureus* isolates to the tested antibiotics is shown in Table 3. Overall, 196 (83.4 %) isolates were MSSA and 39 (16.6 %) were MRSA. As a result of studying of staphylococci tested strains susceptibility to antibiotics it was established, that based on antimicrobial susceptibility analysis, the most active antibiotics found in the study were linezolid, tigecycline, vancomycin, teicoplanin,

Table 2

Univariate and multivariate analysis of potential factors for nasal carriage of methicillin-sensitive and methicillin-resistant *Staphylococcus aureus* among healthcare workers at Ukrainian hospitals

Variable	Carrier status		p-value	Logistic regression	
	MSSA	**MRSA**		**OR (95 % CI)**	**p-value**
Gender:			0.247		0.779
Male	84 (42.9 %)	14 (35.9 %)			
Female	112 (57.1 %)	25 (64.1 %)			
Age, years (Mean ± SD)	33.16 ± 9.3	33.56 ± 7.2	0.817		
Stratified age, years:			0.21		
< 30	93 (47.4 %)	15 (38.5 %)			
30—50	94 (48.0 %)	24 (61.5 %)			
> 50	9 (4.6 %)	0			
Years of working (Mean ± SD)	8.85 ± 7.4	10.98 ± 8.2	0.15		
Stratified years of working:			0.248		
0—9	130 (66.3 %)	21 (53.8 %)			
10—19	46 (23.6 %)	14 (35.9 %)			
20—36	20 (10.2 %)	4 (10.3 %)			
Department / Ward:			0.224		0.788
Internal medicine and pediatrics	57 (29.1 %)	8 (20.5 %)			
Emergency	36 (18.4 %)	8 (21.9 %)			
ICU	11 (5.6 %)	6 (15.4 %)			
Surgery	54 (27.6 %)	13 (33.3 %)			
Non-medical	38 (19.4 %)	4 (10.3 %)			
Occupation			0.032		
Nurse	52 (33.8 %)	17 (53.1 %)		3.6 (1.3—9.7)	0.012
Auxiliary nurse	36 (23.4 %)	9 (28.1 %)		1.3 (0.53—3.3)	

Note. MSSA — methicillin-sensitive *Staphylococcus aureus*; MRSA — methicillin-resistant *Staphylococcus aureus*; OR — odds ratio; CI — confidence interval; ICU — intensive care unit.

and mupirocin, showing growth inhibition of 100 % strains tested. Susceptibility to the other antimicrobials was also on a high level: 98.3 % of strains were found susceptible to trimethoprim/sulphamethoxazole, 96.2 % — to nitrofurantoin, 95.3 % — to fusidic acid, 92.3 % — to fosfomicin, 88.5 % — to amoxicillin/clavulanic acid, 87.2 % — to tobramycin, 86.8 % — to clindamycin.

Susceptibility to levofloxacin (85.5 %), cefoxitin (85.5 %), levofloxacin (85.5 %), rifampicin (85.5 %), tetracycline (81.7 %), erythromycin (81.7 %), and moxifloxacin (79.6 %) was observed to be some lower. Resistance to oxacyllin came up to 16.6 %. Interestingly, penicillin, which is currently not used for treatment of staphylococcal infections anymore, was shown to be ineffective in 60.0 % of strains, which still suggests the usefulness of this antibiotic for patient treatment, based on the individual antibiogram data.

At first glance, taking into account the fact, that levels of antimicrobial resistance of tested strains of *S. aureus* did not exceed 21 %, it seems quite easy to choose any of the above-mentioned antibiotics (excepting benzylpenicillin) to treat staphylococcal infections of any localization. However, analysis of antimicrobial resistance profiles revealed that some strains were resistant to 7—9 antibiotics, belonging to 5—10 classes of antimicrobials. This considerably limits the choice of antibiotics useful for treatment of infections, despite of low levels of resistance among staphylococci in general. Analysis of the profiles for strains resistant to 6 and more classes of antibiotics demonstrated, that all the strains were

Table 3
Antimicrobial susceptibility of *S. aureus* isolated from health-care workers in Ukrainian hospitals

Antibiotic	S	I	R	R (95 % CI)
Penicillin	92 (39.1 %)	2 (0.9 %)	141 (60.0 %)	56.8—63.2
Oxacillin	196 (83.4 %)	0	39 (16.6 %)	14.2—19.1
Cefoxitin	201 (85.5 %)	0	34(14.5 %)	12.2—16.8
Amoxicillin/clavulanic acid	208 (88.5 %)	1 (0.4 %)	26 (11.1 %)	9.1—13.2
Gentamicin	198 (84.3 %)	2 (0.9 %)	35 (14.9 %)	12.6—17.2
Tobramycin	205 (87.2 %)	2 (0,9 %)	28 (11.9 %)	9.8—14.0
Ciprofloxacin	197 (83.8 %)	2 (0.9 %)	36 (15.3 %)	12.9—17.6
Levofloxacin	201 (85.5 %)	1 (0.4 %)	33 (14.0 %)	11.7—15.3
Moxifloxacin	187 (79.6 %)	3 (1.3 %)	35 (14.9 %)	12.6—17.2
Mupirocin	235 (100.0 %)	0	0	0.0
Nitrofurantoin	226 (96.2 %)	0	9 (3.8 %)	2.6—5.0
Vancomycin	235 (100.0 %)	0	0	0.0
Teicoplanin	235 (100.0 %)	0	0	0.0
Fosfomycin	217 (92.3 %)	1 (0.4 %)	17 (7.2 %)	5.6—8.8
Clindamycin	204 (86.8 %)	0	31 (13.2 %)	11.0—15.4
Erythromycin	192 (81.7 %)	2 (0.9 %)	41 (17.4 %)	15.0—19.8
Rifampicin	201 (85.5 %)	2 (0.9 %)	32 (13.6 %)	11.4—15.8
Linezolid	235 (100.0 %)	0	0	0.0
Tetracycline	192 (81.7 %)	2 (0.9 %)	41 (17.4 %)	15.0—19.8
Tigecycline	235 (100.0 %)	0	0	0.0
Trimethoprim/sulphamethoxazole	231 (98.3 %)	0	4 (1.7 %)	0.9—2.5
Fusidic acid	224 (95.3 %)	0	11 (4.7 %)	3.3—6.1

resistant to oxacyllin, suggesting previously shown evidences on multiple antimicrobial resistance among staphylococci, resistant to oxacyllin.

DISCUSSION

There is a paucity of information on the role of human carriage among HCWs, personnel that could easily carry and spread *S. aureus* strains to patients. To the best of our knowledge, the current study is the first on prevalence of *S. aureus* and MRSA among HCWs in Ukrainian hospitals. Laboratory-based screening for MRSA colonisation of HCWs is a key element in enabling control measures and early therapeutic decisions.

An overview of the published work highlights that carriage of MSSA or MRSA in HCWs occurs at a variable rate in countries with very different public health and social structures, however, there is no simple way to predict carriage rates on the basis of the mentioned variables [11, 14, 16, 18, 21, 24—27]. Differences in the prevalence of nasal carriage of *S. aureus* strains may be due in part to differences in the quality and size of samples and the use of different techniques and different interpretation guidelines. Our study of nasal carriage in HCWs in a local public hospital showed that 31 % of the personnel carried *S. aureus* [26, 27], of whom 16.6 % accounted for MRSA [16, 26, 27]; those frequencies are comparable to others reported in the literature. Remarkably, nurses were mainly colonized by MRSA strains rather than MSSA strains (statistically significant, $p < 0.032$ by the Fisher's exact test) than medical doctors.

The frequency of MRSA and MSSA carriage also varies between hospital department/wards. The highest prevalence of nasal carriage of MRSA was in the surgical wards. The staff of the general, pediatric, cardiovascular, neuro and orthopedic surgery wards together with the emergency department accounted for 56.4 % of all MRSA carriers.

All the *S. aureus* isolates recovered from nasal carriers, were susceptible to linezolid, tigecycline, vancomycin, teicoplanin, and mupirocin. Susceptibility to the other antimicrobials was also on a high level (trimethoprim/sulphamethoxazole, nitrofurantoin, fusidic acid, fosfomicin, amoxicillin/clavulanic acid, tobramycin, and clindamycin). Resistance to oxacyllin came up to 16.6 %. Interestingly, penicillin, which is currently not used for treatment of staphylococcal infections anymore, was shown to be ineffective in 60.0 % of strains, which still suggests the usefulness of this antibiotic for patient treatment, based on the individual antibiogram data. There was a relationship between methicillin resistance and resistance to other antibiotics, as noted in previous investigations [28, 29]. Thus, this is a major problem in the treatment of *S. aureus* infections. PCR testing confirmed that all MRSA strains isolated from our HCWs were *mecA* gene-positive. This study was preliminary and the initiation of further molecular studies is required to track *mecA* in our isolates.

Healthcare workers are likely to be important in the transmission of MRSA, but more frequently act as vectors, rather than being the main sources of MRSA transmission [15, 30]. The most important mode of MRSA transmission is through contamination of the hand [31]. An alternative mechanism of transmission is airborne dispersal of staphylococci in association with an upper respiratory tract infection. Colonised HCW are most often transiently colonised, but they may become persistent carriers if they have chronic dermatitis or sinusitis, and this may lead to prolonged MRSA transmission [32].

Whilst routine screening of all potential inpatients at risk is receiving increasing political support, the procedures of screening and decolonisation for colonised HCWs remain controversial [15]. Other issues related to the management of colonised HCWs have been raised in the literature, including the questions of the optimum timing of HCW screening and whether and for how long colonised HCWs should be excluded from work [15]. Work restrictions for HCWs colonised 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 [15].

CONCLUSIONS

Nasal carriage of *S. aureus* appears to play a key role in the epidemiology and pathogenesis of infection. HCWs who are at interface between the hospital and the community may serve as agents of cross contamination of hospital acquired and community acquired MRSA. Laboratory-based screening for MRSA colonisation of HCWs is a key element in enabling control measures and early therapeutic decisions. It is of importance to follow the evolution of resistance to antibiotics in this species, especially to β-lactams.

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Consent for publication
Not applicable.

Ethical considerations
The authors state that the procedures followed conformed to the ethical standards of the responsible human experimentation committee and in agreement with the World Medical Association and the Declaration of Helsinki. Informed oral consent was obtained from all study staff prior to specimen collection. This document is in the possession of the correspondence author. The study was approved by the Shupik National Medical Academy of Postgraduate Education. Ethical considerations including privacy of personal data were considered during all steps of the research.

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Conflict of interest
The authors declare that they have no conflict interests.

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ПОШИРЕНІСТЬ НОСОВОГО НОСІЙСТВА *STAPHYLOCOCCUS AUREUS* ТА ЙОГО АНТИБІОТИКОЧУТЛИВІСТЬ СЕРЕД ПРАЦІВНИКІВ ОХОРОНИ ЗДОРОВ'Я В УКРАЇНІ

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Носове носійство *Staphylococcus aureus* серед працівників закладів охорони здоров'я — поширена причина виникнення внутрішньолікарняних інфекцій. Антибіотикорезистентність мікроорганізмів, особливо штамів *S. aureus*, резистентних до метициліну (MRSA), є серйозною проблемою лікарень.
Мета роботи — визначити поширеність носового носійства *Staphylococcus aureus* серед працівників закладів охорони здоров'я в Україні.
Матеріали і методи. Дослідження проведено із січня до грудня 2017 р. У дослідженні взяли участь працівники 19 лікарень з різних регіонів України. Назальні мазки було взято від 755 випадково вибраних працівників закладів охорони здоров'я. Середній вік учасників становив (32,41 ± 8,29) року (діапазон — 19—74 роки). Співвідношення чоловіків і жінок — 0,47. Ізоляти ідентифіковано як *S. aureus* на підставі морфології, результатів каталазного та коагулазного тесту, а також бродіння агаром солі манітолу. Чутливість до антибіотиків штамів *S. aureus* визначено диско-дифузійним методом (Кірбі — Бауера). Набір антибіотиків, використаних у тестах визначення чутливості: пеніцилін, оксацилін, цефокситин, амоксицилін/клавуланова кислота, гентаміцин, тобраміцин, ципрофлоксацин, левофлоксацин, моксифлоксацин, мупіроцин, нітрофурантоїн, ванкоміцин, тейкопланін, фосфоміцин, кліндаміцин, еритроміцин, рифампіцин, лінезолід, тетрациклін, тігециклін, триметоприм/сульфаметоксазол та фузидієва кислота. Для оцінки результатів чутливості до антибіотиків використовували критерії, запропоновані Інститутом клінічних та лабораторних стандартів США (CLSI). Штами MRSA верифіковано на підставі виявлення гена *mecA* за допомогою полімеразної ланцюгової реакції.
Результати та обговорення. Скринінг мазків з носа визначив 31,1 % (235/755) носіїв *S. aureus*, з них 83,4 % (196/755) були носіями штамів MSSA (метицилін-чутливий *S. aureus*), решта — MRSA. Частота носійства штамів MRSA та MSSA варіювала залежно від профілю відділення лікарні. Найвищий рівень поширеності носового носійства штамів MRSA виявлено серед працівників хірургічних відділень. На частку співробітників відділень загального профілю, педіатрії, серцево-судинних, нейро- та ортопедичних хірургічних, невідкладної допомоги припадало 56,4 % від усіх носіїв MRSA. Не виявлено суттєвої відмінності за статтю (p = 0,247), віком (p = 0,817) і тривалістю роботи в закладах охорони здоров'я (p = 0,15) щодо носового носійства штамів MRSA та MSSA. За результатами однофакторного аналізу серед працівників відділень невідкладної та внутрішньої медицини, педіатрії, адміністративного, хірур-

гічного та немедичних підрозділів не виявили істотної відмінності між носіями штамів MRSA та MSSA (p = 0,224). Багатоваріантний аналіз показав, що медсестри були пов'язані з ризиками інфікування та носійства штамів MRSA (p = 0,012, відношення шансів — 3.6, 95 % довірчий інтервал — 1,3—9,7). Усі ізоляти *S. aureus*, виділені від носових носіїв, були чутливі до лінезоліду, тігецикліну, ванкоміцину, тейкопланіну та мупіроцину. Сприйнятливість до інших антибактеріальних препаратів була також високою: 98,3 % — до триметоприму/сульфаметоксазолу, 96,2 % — до нітрофурантоїну, 95,3 % — до фузидієвої кислоти, 92,3 % — до фосфоміцину, 88,5 % — до амоксициліну/клавуланової кислоти, 87,2 % — до тобраміцину, 86,8 % — до кліндаміцину. Стійкість до оксациліну становила 16,6 %.

Висновки. Носове носійство *S. aureus*, імовірно, відіграє ключову роль в епідеміології та патогенезі інфекції. Працівники закладів охорони здоров'я можуть бути джерелом перехресного зараження як внутрішньолікарняними, так і позалікарняними інфекціями, спричиненими штамами MRSA. Важливо стежити за еволюцією стійкості до антибіотиків цього виду, особливо до β-лактамів.

Ключові слова: *Staphylococcus aureus*, носове носійство, працівники закладів охорони здоров'я, антибіотикорезистентність, MRSA, Україна.

РАСПРОСТРАНЕННОСТЬ НОСОВОГО НОСИТЕЛЬСТВА *STAPHYLOCOCCUS AUREUS* И ЕГО АНТИБИОТИКОРЕЗИСТЕНТНОСТЬ СРЕДИ СОТРУДНИКОВ УЧРЕЖДЕНИЙ ЗДРАВООХРАНЕНИЯ УКРАИНЫ

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Носовое носительство *Staphylococcus aureus* среди работников учреждений здравоохранения — распространенная причина возникновения внутрибольничных инфекций. Антибиотикорезистентность *S. aureus*, особенно штаммов MRSA (метициллин-резистентный *S. aureus*), является серьезной проблемой для больниц.

Цель работы — определить распространенность носового носительства *S. aureus* и его чувствительность к антибиотикам среди работников учреждений здравоохранения в Украине.

Материалы и методы. Исследование проведено в период с января по декабрь 2017 г. В исследовании приняли участие работники 19 больниц из разных регионов Украины. Назальные мазки взяты от 755 случайно выбранных работников учреждений здравоохранения. Средний возраст участников составил (32,41 ± 8,29) года (диапазон — 19—74 года). Соотношение мужчин и женщин — 0,47. Изоляты идентифицировали как *S. aureus* на основании морфологии, результатов каталазного и коагулазного теста, а также брожения агаром соли маннитола. Чувствительность к антибиотикам штаммов *S. aureus* определяли диско-диффузным методом (Кирби — Бауэра). Набор антибиотиков, использованный в тестах определения чувствительности: пенициллин, оксациллин, цефокситин, амоксициллин/клавулановая кислота, гентамицин, тобрамицин, ципрофлоксацин, левофлоксацин, моксифлоксацин, мупироцин, нитрофурантоин, ванкомицин, тейкопланин, фосфомицин, клиндамицин, эритромицин, рифампицин, линезолид, тетрациклин, тигециклин, триметоприм/сульфаметоксазол и фузидиевая кислота. Для оценки результатов чувствительности к антибиотикам использовали критерии, предложенные Институтом клинических и лабораторных стандартов США (CLSI). Штаммы MRSA верифицировали на основании выявления гена *mecA* с помощью полимеразной цепной реакции.

Результаты и обсуждение. Скрининг мазков из носа определил 31,1 % (235/755) носителей *S. aureus*, из них 83,4 % (196/755) были носителями штаммов MSSA (метициллин-чувствительный *S. aureus*), остальные — MRSA. Частота выявления носительства штаммов MRSA и MSSA варьировала в зависимости от профиля отделения больниц. Наивысший уровень распространенности носового носительства штаммов MRSA выявлен среди работников хирургических отделений. Доля сотрудников отделений общего профиля, педиатрии, сердечно-сосудистых, нейро- и ортопедических хирургических, неотложной помощи составила 56,4 % от всех носителей штаммов MRSA. Не было существенного отличия по полу (p = 0,247), возрасту (p = 0,817) и длительности работы в учреждении здравоохранения (p = 0,15) для носового носительства штаммов MRSA и MSSA. По результатам однофакторного анализа среди работников отделений неотложной и внутренней медицины, педиатрии, административного, хирургических и немедицинских подразделений не выявили существенного отличия между носителями штаммов MRSA и MSSA (p = 0,224). Многовариантный анализ показал, что медсестры были связаны с риском инфицирования и носительства штаммов MRSA (p = 0,012, отношение шансов — 3.6, 95 % доверительный интервал — 1,3—9,7). Все изоляты *S. aureus*, выделенные от носовых носителей, были чувствительны к линезолиду, тигециклину, ванкомицину, тейкопланину и мупироцину. Восприимчивость к другим антибактериальным препаратам была также высокой: 98,3 % — к триметоприму/сульфаметоксазолу, 96,2 % — к нитрофурантоину, 95,3 % — к фузидиевой кислоте, 92,3 % — к фосфомицину, 88,5 % — к амоксициллину/клавулановой кислоте, 87,2 % — к тобрамицину, 86,8 % — к клиндамицину. Устойчивость к оксациллину составила 16,6 %.

Выводы. Носовое носительство *S. aureus*, вероятно, играет ключевую роль в эпидемиологии и патогенезе инфекции. Работники учреждений здравоохранения могут быть источником перекрестного заражения как внутрибольничными, так и внебольничными инфекциями, вызванными штаммами MRSA. Важно наблюдать за эволюцией устойчивости к антибиотикам этого вида, особенно к β-лактамам.

Ключевые слова: *Staphylococcus aureus*, носовое носительство, сотрудники учреждений здравоохранения, антибиотикорезистентность, MRSA, Украина.

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