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NASAL CARRIAGE OF STAPHYLOCOCCUS AUREUS AMONG HEALTHCARE WORKERS IN KHARKIV MEDICAL FACILITIES

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The study was devoted to the problem of Staphylococcus aureus carriage among employees of medical institutions in Kharkiv in order to objectively investigate bacterial carriage as one of the causes of the spread of nosocomial infections. 309 employees of medical institutions in Kharkiv were examined. It was found that 31.7 % of those examined were carriers of *S. aureus*. Among all the isolated *S. aureus* isolates, 40 % were resistant to methicillin, and 3.5 % were resistant to vancomycin. To determine the routes of intrahospital spread of *S. aureus* and identify possible sources of infection, we performed phage typing on the isolated *S. aureus* isolates. It was found that in the surgical and somatic departments, *S. aureus* isolates of phage types 2 and 3 prevailed. This indicates their epidemiological significance. The results of our study on Staphylococcus aureus carriage among medical personnel in Kharkiv hospitals emphasize the need to establish systematic surveillance and preventive strategies aimed at reducing the risk of healthcare-associated infections.

Key words: nosocomial infections, staphylococcal infections.

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НАЗАЛЬНЕ НОСІЙСТВО STAPHYLOCOCCUS AUREUS СЕРЕД МЕДИЧНИХ ПРАЦІВНИКІВ ХАРКІВСЬКИХ ЛІКУВАЛЬНИХ ЗАКЛАДІВ

Стаття присвячена проблемі носійства Staphylococcus aureus серед працівників медичних установ м. Харкова з метою об'єктивно дослідити бактеріоносійство як одну з причин поширення нозокоміальних інфекцій. Було обстежено 309 працівників медичних закладів м. Харкова. Встановлено, що носіями *S. aureus* були 31,7 % обстежених. Серед всіх вилучених ізолятів *S. aureus* резистентними до метициліну були 40 %, а резистентними до ванкоміцину – 3,5 % ізолятів. Для визначення шляхів внутрішньолікарняного розповсюдження *S. aureus* та виявлення можливих джерел інфікування нами було проведено фаготипування у вилучених ізолятів *S. aureus*. Встановлено, що у відділеннях хірургічного і соматичного профілю превалювали ізоляти *S. aureus* фаготипів 2 і 3 груп. Зазначене свідчить про їхню епідеміологічну значущість. Результати нашого дослідження щодо носійства Staphylococcus aureus серед медичного персоналу в лікарнях Харкова підкреслюють необхідність встановлення систематичного нагляду та профілактичних стратегій, спрямованих на зниження ризику інфекцій, пов'язаних із наданням медичної допомоги.

Ключові слова: нозокоміальні інфекції, стафілококові інфекції.

The study is a fragment of the research project “Development of new approaches to overcoming staphylococcal carriage in risk groups”, state registration No. 0125U000252.

Currently, the problem of hospital-acquired infections (HAIs) is becoming increasingly significant worldwide, and particularly in Ukraine. This is due to the expansion of medical care as a result of the neighboring country's aggression, the widespread implementation of surgical treatment methods, and the growing antibiotic resistance of microorganisms.

HAIs are defined as any clinically manifested microbial disease that affects a patient as a result of hospitalization or a visit to a healthcare facility, as well as hospital personnel due to their professional activities, regardless of whether the symptoms of the disease appear during the individual's stay in the hospital [2, 3]. In other words, hospital-acquired infections represent one of the most pressing issues in modern medicine, as their relevance stems from high morbidity and mortality rates and substantial socio-economic losses.

Staphylococcal infections are among the most urgent nosocomial infections [2]. In recent years, the issue of nosocomial infections, including those caused by Staphylococcus spp., has gained a global dimension and requires comprehensive analysis and the development of modern control strategies. Only a multidisciplinary approach and the application of up-to-date methods and interventions can ensure success.

Staphylococci are conditionally pathogenic members of the normal microbiota of human and warm-blooded animal skin and mucous membranes. They lack strict tissue or organ tropism and therefore may cause inflammatory processes in the skin, subcutaneous tissue, and mucosa (e.g., furuncles, carbuncles, abscesses, dermatitis, conjunctivitis); bone tissue (osteomyelitis); internal organs (pneumonia,

appendicitis, cholecystitis, meningitis); peritonitis; and even sepsis [4, 5]. While all individuals are carriers of coagulase-negative staphylococci, *Staphylococcus aureus* is isolated from the upper respiratory tract mucosa of approximately 30 % of healthy individuals in the general population [2–5].

The percentage of *S. aureus* carriers is significantly higher – up to 80 % – among healthcare workers, patients with eczematous skin conditions, and individuals who undergo frequent injections, such as patients with insulin-dependent diabetes, allergies, or those receiving hemodialysis [6–9]. Practically healthy carriers are considered the most common source of *S. aureus* [10].

Traditional methods for decolonization using antibacterial drugs are largely ineffective, as carriage often recurs over time and requires repeated treatment courses. Repeated antibiotic therapy, in turn, leads to further suppression of the host immune system and promotes the development of antibiotic resistance in microbial strains [1, 11]. It is known that bacterial carriage causes a restructuring of host defense mechanisms, resulting in immunological imbalance [11]. Given recent data on the role of the microbiome, it can be hypothesized that bacterial carriage involves complex mechanisms and thus requires a combination of treatment strategies.

The purpose of the study was to identify and select relevant *S. aureus* strains for further development of a new class of immunobiological drugs based on screening and epidemiological assessment of carriage among employees of medical institutions in Kharkiv.

Materials and methods. The material was obtained from the Military Medical Clinical Center of the Northern Region and the Municipal Profit-Making Enterprise “Kharkiv Student Hospital” of the Kharkiv City Council in 2025. The study was carried out at the State Institution “Mechnikov Institute of Microbiology and Immunology of the National Academy of Medical Sciences of Ukraine”.

The total group of medical and technical staff from the surgical and somatic departments of hospitals in Kharkiv included 309 individuals (246 women and 63 men) aged 26–70 years. To detect healthy carriers of *S. aureus*, nasal swabs were collected from them. The examination was performed every 3 months. If *S. aureus* was re-extracted, carriage was considered positive. If *S. aureus* was not re-extracted, carriage was considered negative.

All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki (World Medical Association) for medical research involving human subjects, the European Community Directive 86/609/EEC on the protection of individuals in biomedical studies, and the Order of the Ministry of Health of Ukraine No. 690 (September 23, 2009). The study protocol was approved by the Ethics and Bioethics Committee of the State Institution “Institute of Microbiology and Immunology of the National Academy of Medical Sciences of Ukraine” (Extract from Protocol No. 3, February 20, 2025). Written consent was obtained from the employee before participating in the study.

Identification of *S. aureus* isolates and determination of their antimicrobial susceptibility profiles were performed using an automated microbiological analyzer VITEK® 2 Compact with VITEK® AST-P644 test cards (bioMérieux, France). The antibiotic susceptibility of the identified strains was determined according to the current guidelines of the European Committee on Antimicrobial Susceptibility Testing (EUCAST). Based on susceptibility to cefoxitin and vancomycin, *S. aureus* isolates were classified as methicillin-resistant (MRSA) or vancomycin-resistant (VRSA). Methicillin resistance was assessed using cefoxitin (30 µg) discs, and vancomycin resistance was assessed using vancomycin (30 µg) discs (Pharmactiv LLC, Ukraine). Based on the resistance profiles to cefoxitin and vancomycin, the *S. aureus* strains were classified into methicillin-resistant (MRSA) and vancomycin-resistant (VRSA) groups.

Phage typing of the isolated *S. aureus* strains plays an important role in epidemiological surveillance. Phage typing is based on the specific lysis of staphylococci by bacteriophages. This method is used in epidemiological analysis, particularly to identify the source and transmission routes of infection. Coagulase-positive strains are subjected to phage typing. The International Subcommittee on Phage Typing of Staphylococci recommends a set of 23 typical bacteriophages, grouped based on their lytic affinity into four groups [16].

For phage typing, an international set of temperate phages, divided into four groups, was used:

Group 1: Phages 29, 52, 52A, 79, 80

Group 2: Phages 3A, 3C, 55, 71

Group 3: Phages 6, 42E, 47, 53, 54, 75, 77, 84, 85

Group 4: Phages 94, 95, 96

Out of Group: Phages 81, 187.

Phage typing was performed using commercial test kits (bioMérieux, France).

The statistical analysis of the data was carried out according to the principles of variation statistics, as described in standard manuals [17]. In each case, p-values were calculated for the analyzed variables

using Fisher's exact test and the chi-square test, considering p -values $< 0,05$ as statistically significant. Statistical data analysis was performed using Biostat-4 (StatSoft Inc., USA), Statistica 10.0 (StatSoft Inc., USA), and Microsoft Excel 2003 (Microsoft Corp., USA).

Results of the study and their discussion. The studied population of healthcare workers in Kharkiv ($n=309$) exhibited significant gender bias, with a predominance of female participants (71.2 % women and 28.8 % men, which is due to martial law and the active call-up of men to the ranks of the Armed Forces of Ukraine). The participants were grouped into five age categories: 20–29 years (16.5 %), 30–39 years (26.3 %), 40–49 years (27.8 %), 50–59 years (25.2 %), and those aged 60 years and older (4.2 %). Screening for *S. aureus* carriage revealed the presence of this bacterium in 31.7 % of the examined individuals (Table 1). The distribution of carriers by profession showed that the highest number of carriers was among nurses (37.8 %), followed by doctors (31.6 %) and junior nurses (17.4 %). Regarding other positions, the distribution of carriers was as follows: administrative staff – 8.2 %, technical staff – 5.0 %.

Table 1

Distribution of *S. aureus* carriers by age and profession

Position	Number of people (tested/carriers)					
	Total	20–29 years	30–39 years	40–49 years	50–59 years	60–70 years
Doctors	85/31	0	12/5	31/13	34/11	8/2
Nurses	128/37	38/6	39/11	30/17	21/3	0
Administrative staff	23/8	0	8/3	7/3	5/2	3/0
Technical staff	18/5	0	5/1	7/2	6/2	0
Nursing assistant	55/17	13/4	17/5	11/4	12/3	2/1
Total	309/98	51/10	81/25	86/39	78/21	13/3

The highest percentage of carriers was observed in the 40–49 years age group (39.8 %), while the lowest percentage was found in the 60–70 years age group (3.1 %). This result, in our opinion, is influenced by the smaller sample size in the 60–70 years age group.

It was determined that the majority of doctors were in the 40–59 years age group, while the majority of nurses and junior nurses were in the 20–39 years age group.

Among the examined doctors, 36.5 % were carriers, among nurses 28.9 %, and among administrative and technical staff, 34.8 % and 27.8 %, respectively. The highest percentage of *S. aureus* carriers was observed among the doctors and administrative staff.

A comparative statistical analysis was performed, which showed that among the medical personnel of somatic departments, the carrier rate was 25.5 %, while among the medical personnel of surgical departments, the carrier rate was 40.5 %. (Table 2).

Table 2

Distribution of carriers by department and professional category

Position	Department		Total (tested/carriers)
	Somatic profile (tested/carriers)	Surgical profile (tested/carriers)	
Doctors	54/17	31/14	85/31
Nurses	72/16	56/21	128/37
Nursing assistant	31/7	24/10	55/17
Total	157/40	111/45	268/85

An analysis of the distribution of carriers by professional category among the examined medical staff revealed the following: among physicians working in somatic departments, 31.5 % were carriers of *S. aureus*; among nurses, the proportion was 22.2 %, and among nurse assistants, 25.5 %.

As for the medical personnel in surgical departments, the highest proportion of carriers was observed among physicians (45.2 %) and nurse assistants (41.7 %), while 37.5 % of surgical nurses were found to be carriers.

An analysis of the distribution of carriers by department showed that the prevalence of *S. aureus* carriers in surgical departments was statistically significantly higher according to the chi-square test and Fisher's exact test ($p < 0,05$), compared to somatic departments.

There are strains of *S. aureus* that are resistant to major classes of antibiotics. Methicillin-resistant strains are referred to as methicillin-resistant *S. aureus* (MRSA); they are unresponsive to most β -lactam antibiotics and frequently cause nosocomial infections, as the diseases they cause are difficult to treat and require the use of specialized antibiotics. Strains resistant to vancomycin are known as vancomycin-resistant *S. aureus* (VRSA). These are more dangerous than MRSA strains, and their presence significantly complicates treatment, thereby increasing the risk of fatal outcomes.

As a result of the antibiotic resistance analysis of the strains isolated from carriers, it was found that 40 % of all isolated *S. aureus* strains were resistant to methicillin, and 3.5 % were resistant to vancomycin.

MRSA strains were isolated in 12.9 % of physicians, 10.9 % of nurses, 5.5 % of nurse assistants, and in 17.3 % and 11.1 % of administrative and technical staff, respectively.

VRSA strains were isolated in only 0.97 % of the examined personnel: among physicians, VRSA was identified in 1.2 % of cases, and among nurses, in 1.6 %. No VRSA isolates were detected among nurse assistants, administrative, or technical staff. Thus, it was determined that the number of MRSA isolates among carriers was relatively significant—34 out of 85 isolates—whereas the number of VRSA strains was minimal, with only three isolates identified. Statistical analysis using the chi-square test and Fisher's exact test demonstrated that physicians and nurses were significantly more likely ($p < 0,05$) to be carriers of MRSA and VRSA compared to administrative, technical, and nurse assistant staff. In our view, this may be associated with more prolonged and frequent contact with patients and among themselves.

In the age group of 20–29 years, the percentage of MRSA carriers was 9.8 %, while no VRSA carriers were identified. In the 30–39 age group, 9.9 % were carriers of MRSA and 1.2 % of VRSA. Among individuals aged 40–49, 9.3 % were carriers of MRSA and 2.3 % of VRSA. In the 50–59 age group, 9.0 % were MRSA carriers, and no VRSA isolates were detected. Among the examined individuals aged 60–70 years, neither MRSA nor VRSA carriers were identified. This may be attributed to the relatively small number of individuals examined in this age group compared to others.

To identify possible routes of transmission and potential sources of infection, we conducted an epidemiological analysis of the isolated *S. aureus* strains by phage typing.

Phage typing analysis showed that, in somatic departments, the most frequently isolated strains belonged to phage group 2 (42.5 %). Strains of group 3 accounted for 32.5 % of all isolates. Phage groups 1 (10 %) and 4 (7.5 %), as well as ungrouped phages (7.5 %), were detected less frequently. In contrast, in surgical departments, *S. aureus* strains of phage groups 3 (51.1 %) and 2 (26.7 %) predominated. The distribution of *S. aureus* strains by other phage groups in surgical departments was as follows: group 1 – 15.6 %, group 4 – 4.4 %, and ungrouped – 2.2 %.

The high prevalence of *S. aureus* strains belonging to phage groups 2 and 3 indicates their epidemiological significance and may suggest a high risk of nosocomial infections of staphylococcal origin.

We also performed a phage typing analysis among the examined personnel by occupation. Among physicians, *S. aureus* strains of phage group 3 (41.9 %) and group 4 (35.5 %) predominated, followed by group 2 strains (12.9 %) and ungrouped strains (9.7 %).

Among nurses, *S. aureus* strains of phage group 3 were also predominant (45.9 %), followed by strains of group 2 (29.7 %). In terms of prevalence, they were followed by strains of phage groups 1 (16.2 %) and 4 (8.2 %). No phage-untypable *S. aureus* strains were identified among nurses.

Among technical staff, strains belonging to phage groups 3 and 4 were equally distributed (40 % each), while group 2 accounted for 20 %. In administrative personnel, *S. aureus* strains from phage groups 2 (37.5 %), 3 (37.5 %), and 4 (25.0 %) were predominant. As for nurse assistants, strains of all phage groups were found: group 1 – 23.5 %, group 2 – 29.4 %, group 3 – 23.5 %, group 4 – 11.8 %, and 11.8 % were untypable. This may be attributed to the broader range of tasks and interpersonal interactions involved in the duties of nurse assistants.

Statistical analysis using the chi-square test and Fisher's exact test demonstrated that, compared to other occupational categories, physicians and nurses were significantly more likely ($p < 0,05$) to harbor *S. aureus* strains of phage group 3.

To summarize the results of the epidemiological analysis: physicians carried *S. aureus* strains of phage groups 2, 3, and 4, as well as untypable strains; nurses carried strains from phage groups 1, 2, 3, and 4; administrative and technical staff carried strains from groups 2, 3, and 4; while nurse assistants harbored strains from all phage groups.

Our findings regarding nasal carriage of *S. aureus* are consistent with published data [6, 7, 9]. We demonstrated that the prevalence of *S. aureus* carriers was 1,5 times higher ($p < 0,05$) among personnel of surgical departments compared with those in somatic (therapeutic) departments. This may be attributed to increased exposure to patients and the surgical environment, where the microbial load and frequency of contact are typically higher. Similar observations have been reported by foreign researchers, who also noted a higher carriage rate among staff in surgical units [6, 7].

In our study, we found that among medical personnel in surgical departments, the prevalence of *S. aureus* carriage was 1,5 times higher ($p < 0,05$) compared to staff in somatic departments. We hypothesize

that this increased carriage rate in surgical units may be associated with more frequent contact with patients and exposure to the operative milieu's microflora. Similar observations have been reported in international studies, which also note a higher prevalence of *S. aureus* carriers among surgical staff [9].

Our investigation of the circulation of shared hospital phage types of *S. aureus* revealed a specific phage-variant distribution across different hospital units: the pattern of phage type prevalence was similar in the surgical and somatic departments, suggesting the presence of common, circulating *S. aureus* strains within the hospital environment, regardless of department profile.

Modern immunobiological research increasingly leverages the unique characteristics of both pathogenic and beneficial bacteria for therapeutic innovation. A critical step in this process is the selection of microbial strains that are both epidemiologically relevant and clinically significant within a target population [16–18]. We determined the epidemiological significance of the circulating *S. aureus* strains and selected 33 relevant isolates for further work.

The limitations of the work include the inability to compare carrier rates between women and men.

Conclusion

The results of this study demonstrated that 31.7 % of healthcare workers examined were nasal carriers of *S. aureus*, while 11.0 % were carriers of methicillin-resistant *S. aureus* (MRSA). The prevalence of *S. aureus* carriage among staff of surgical departments was 1.5 times higher ($p < 0,05$) compared with personnel from somatic (therapeutic) departments.

Among all isolated *S. aureus* strains, 34.7 % were methicillin-resistant (MRSA) and 3.1 % were vancomycin-resistant (VRSA). In both surgical and somatic departments, *S. aureus* strains of phage groups III (40 %) and II (23.5 %) predominated. The high prevalence of these specific phage groups indicates their epidemiological significance and underscores the risk of hospital-acquired infections of staphylococcal origin. The obtained results enabled the selection of 33 relevant *S. aureus* strains for further use in the development of a combined mucosal candidate vaccine.

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