

Multidrug-resistant *Staphylococcus aureus* isolated from the hands and nasal cavity of professionals in a surgical center

Staphylococcus aureus multirresistentes isolados de mãos e cavidade nasal de profissionais de um centro cirúrgico

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Abstract

Multidrug-resistant *Staphylococcus aureus* has often been found in the hands and nasal cavity of human beings and is among the leading causes of nosocomial infections. Our objective was to verify the presence of *S. aureus* in the hands and nasal cavity of 27 professionals from the operating room in a hospital. The samples were collected with a sterile swab previously moistened with saline solution and later were spread in plates containing Salt Mannitol agar. Characteristic colonies were confirmed by Gram-staining and biochemical tests. The Antibiotic susceptibility test was performed using the disk diffusion technique described by Kirby-Bauer. 40.7% (11) of the professionals have *S. aureus* in the nasal cavity. 14.81% (4) of the professionals presented *S. aureus* in their hands in only one of the collections. Of the 36 strains of *S. aureus* isolated, 11.11% are methicillin resistant, 77.8% showed resistance to penicillin, amoxicillin/clavulanic acid and ampicillin/sulbactam and 58.3% were multidrug resistant. The sensitivity of strains observed mainly to ciprofloxacin (97.22%) and nitrofurantoin (97.22%). The results allow us to conclude that the number of *S. aureus* carriers is relatively high and that the isolated strains are multidrug-resistant, mainly for the antibiotics of first choice used to control common infections.

Keywords

Staphylococcus aureus; Health Personnel; Antimicrobial resistance; Hospital infection

INTRODUCTION

Staphylococcus aureus, which is a commensal and human pathogen, is commonly found in the nasal cavity, however it can also colonize the skin and mucosa. The bacterium is responsible for a wide variety of infections, ranging from skin infections to life-threatening bacteremia infections.⁽¹⁾

This bacterium is a pathogen that evolved to acquire genes and characteristics associated with increased antibiotic resistance, virulence and transmissibility.⁽²⁾

Several studies have been carried out in hospitals around the world to demonstrate the incidence of *S. aureus* on the surface of the hands and nasal cavities of healthcare

professionals. In Brazil, Gomes *et al.*⁽³⁾ reported that 33.1% of professionals in the pediatric department were carriers, and of these, 5.1% were carriers of methicillin resistant strains (MRSA). Varghese *et al.*,⁽⁴⁾ also demonstrated that 36.7% of health professionals in the surgery and orthopedics department had *S. aureus*, with 2.93% having MRSA.

Although the literature review indicates that there is considerable variation, it is reported that nasal MRSA carriers vary between 6.3 and 17.8% in the general population and between 18.2 and 43.8% among health professionals.^(5,6) However, transmission from person to person and from health professional to patients is one of the main concerns in healthcare services.^(7,8)

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S. aureus infections are responsible for approximately 10% of hospital infections and the mortality attributed to bacteremia in children has been reported as 0.7%-5.1%, and up to a third of patients with *S. aureus* develop complications such as bacteremia, endocarditis, pneumonia, sepsis and vancomycin treatment.⁽⁹⁾

In addition to the incidence of this bacterium in hospital environments, one of the biggest problems is the resistance to antimicrobials developed by *S. aureus*, which makes its removal difficult and, consequently, the control of infections.⁽¹⁰⁾

The rise of antimicrobial-resistant *S. aureus* and the steady increase in rates of methicillin-resistant *S. aureus* (MRSA) pose a greater risk and burden to health services worldwide, presenting global health issues.⁽¹¹⁾

In the last few years, several studies have shown that in patients treated with cardiac, orthopedic and spine surgery, nasal colonization of *S. aureus*, especially MRSA, can increase the risk of acquiring infections after surgery.⁽¹²⁾ Thus, since infections at the surgical site are frequent, often requiring prolonged hospitalizations, elongated treatments with antibiotics and additional surgical procedures, control and prevention measures are necessary.⁽¹³⁾

Thus, in view of the above, the present study aimed to identify the presence of *S. aureus* on the surfaces of the hands and nasal cavity of professionals working in the operating room at a hospital; considering that they are subject to colonization by typically hospital microorganisms and they are often multiresistant; placing them in the condition of carriers, disseminators and responsible for outbreaks of nosocomial infections. In addition, they act in contact with the patient during the pre-operative period until the post-operative period, with the possibility of transferring multiresistant strains of *S. aureus*, increasing the risk of infections since the patient is exposed during and after the surgery.

MATERIAL AND METHODS

The methodological procedures were performed at the Research and Diagnostic Laboratory in Microbiology at UNOESC, Campus of São Miguel do Oeste. To carry out this research, this project was submitted to the University's ethics committee, having been approved under protocol number 3.818.499.

Sample collection

Sample collections were carried out in inside of nasal cavity and in the hands of 27 healthcare professionals. They had worked in the hospital's operating room, used as criteria for choosing the participants of this study.

The nasal cavity samples were collected by rotating a sterile swab previously moistened with saline solution in both nostrils of the participants of the present study.⁽¹⁴⁾

The collection of samples from the hands of the participants, in turn, was performed with a sterile swab previously moistened with saline solution, which was rubbed three times on each finger of the hand, in the region between the fingers and inside of the hands.

All swabs from both nasal swabbing were transported inside tubes containing saline solution, packed in a thermal box and subsequently taken to the laboratory for analysis.

The sample collections were performed monthly by a nurse from the hospital, from August to December 2019, always the same professionals.

Isolation and identification of *S. aureus*

All samples from the nasal cavity and hands were used for inoculation onto plates containing the selective medium (Sal Mannitol agar) and incubated in a bacteriological incubator at $36 \pm 1^\circ\text{C}$ for 24-48 hours. Characteristic (yellow) colonies were confirmed by Gram staining and specific biochemical tests for the identification of *S. aureus*, according to Koneman *et al.*⁽¹⁵⁾ and Maccfadin.⁽¹⁶⁾ The confirmed strains for *S. aureus* were subjected to the antimicrobial susceptibility test.

Antibiotic sensitivity test

The antimicrobial susceptibility test was performed using the disk diffusion technique described by Kirby-Bauer according to the methodology recommended by the Brazilian committee on antimicrobial susceptibility testing - BR Cast.⁽¹⁷⁾

The strains were inoculated in Nutrient broth, being incubated at $36 \pm 1^\circ\text{C}$ for approximately 6 hours. After this period, the density of the suspension was compared and adjusted to the standard 0.5 of Macfarland.

Subsequently, with the aid of a swab, the samples were inoculated and spread on the surface of plates containing Mueller-Hinton agar, taking care to obtain a uniform spreading.

Then, the bio-disks were placed on the agar surface, with the aid of sterile forceps and applying light pressure on the disc, to obtain an adherence on the surface of the medium. Each one was positioned in a way to maintain a distance of 3 cm between them.

Susceptibility to the following antimicrobials was evaluated: oxacillin (1µg), penicillin (10µg), clindamycin (2µg), tetracycline (30µg), erythromycin (15µg), sulfazotrim (25µg), rifampicin (5mcg), amoxicillin / clavulanic acid (30µg), cefazolin (30µg), azithromycin (15µg), ampicillin / sulbactam (20 µg), gentamicin (10 µg), amikacin (30µg), cefoxitin (30µg), nitrofurantoin (300µg), ciprofloxacin (5µg), cefotaxime (30µg). In this study, the strain *S. aureus* ATCC 25923 was used as a control.

The results were read after 16-20 hours of incubation, by measuring the halos, with the aid of a millimeter ruler and table for reading the sensitivity to antimicrobials.

Were characterized as multidrug-resistant microorganisms those resistant to three or more classes of antimicrobials.⁽¹⁸⁾

Prevalence of *S. aureus* and MRSA in healthcare professionals

Professionals who presented the bacteria at least twice during the study were considered as carriers of *S. aureus*. In addition, a professional who had a strain of *S. aureus* with an inhibition zone <22 mm for cefoxitin was considered as carrier of MRSA.⁽¹⁷⁾

To discuss the results, the strains isolated from the nasal cavity were called N1 to N27 and M1 to M27 were the strains isolated from the hands of healthcare professionals.

STATISTICAL ANALYSIS

The analysis of the patterns of antimicrobial sensitivity of *S. aureus* and colonization was performed with the SPSS version 16 package (SPSSInc., Chicago, IL, USA). The findings were analyzed statistically using descriptive statistics, frequency and percentage.

RESULTS

Sociodemographic characteristics

The age of the 27 participants varied between 20 and 50 years (average of 34.4 years). Sixteen were females (59.2%) and eleven males (40.7%).

Prevalence of *S. aureus* in the hands and nasal cavities of health professionals

The results showed that 40.7% (11) of the professionals in the hospital's surgical center have *S. aureus* in the nasal cavity, that is, they presented this bacterium at least twice during the performance of this study. 14.81% (4) of the professionals presented *S. aureus* on their hands in only one of the sample collections.

36 strains of *S. aureus* were isolated during the study, in which the second collection was the one with the highest (14) number of strains (Table 1).

The prevalence rate of *S. aureus* in healthcare professionals at the hospital's surgical center was very

similar in all three sample collections. In the first collection, 37% had *S. aureus* only in the nasal cavities and 3.7% only in the hands. In the second collection, 11 (40.7%) strains were isolated from the nasal cavity and 3 (11.1%) from the hands, and all professionals who presented the microorganism on the surface of the hands also presented in the nasal cavity. In the third collection, 11 (40.7%) of the strains were isolated from the nasal cavity and no strains were isolated from the hands.

The results showed that the prevalence of *S. aureus* was higher in the nasal cavity when compared to the number of strains isolated from the hands of healthcare professionals (Figure 1).

Antimicrobial susceptibility profile of isolated *S. aureus* strains

The susceptibility profile of the 36 strains of *S. aureus* isolated from the hands and nasal cavity of healthcare professionals demonstrated that the strains showed resistance of 77.78% to penicillin, amoxicillin / clavulanic acid and ampicillin / sulbactam (Table 2).

The antimicrobials in which the strains were most sensitive were cefazolin (88.89%), cefotaxime (88.89%), cefoxitin (88.89%), oxacillin (88.89%), gentamicin (91.67%), nitrofurantoin (97.22%) and ciprofloxacin (97.22%) (Table 2).

In addition, our results showed that of the 36 strains of *S. aureus* isolated during the three collections performed in the hands and nasal cavities of health professionals, 21 (58.3%) are multi-resistant, of which seven (19.4%) showed multidrug resistance for at least five different classes of antimicrobials.

Prevalence of MRSA in healthcare professionals

The results of this study showed that only one professional had strains of MRSA. As three collections were performed during the execution of this study, 4 strains of MRSA were isolated from the only professional carrier, three of them in the nasal cavity and one of them on the surface of the hands.

The susceptibility profile of MRSA strains shows that they are multidrug-resistant, in which all strains showed resistance to penicillin, amoxicillin / acid. clavulanic, cefazolin, ampicillin / sulbactam, oxacillin, cefotaxime and cefoxitin (Table 3).

Table 1 - Number of strains of *S. aureus* isolated from the nasal cavity and the surface of the hands of professionals in the operating room of a hospital.

Collect	Department	Professionals (n)	<i>S.aureus</i> strains in nasal cavity	<i>S.aureus</i> strains on the surface of the hands	MRSA positive
1	Operating Room	27	10	1	1
2	Operating Room	27	11	3	2
3	Operating Room	27	11	0	1
Total strains			36		

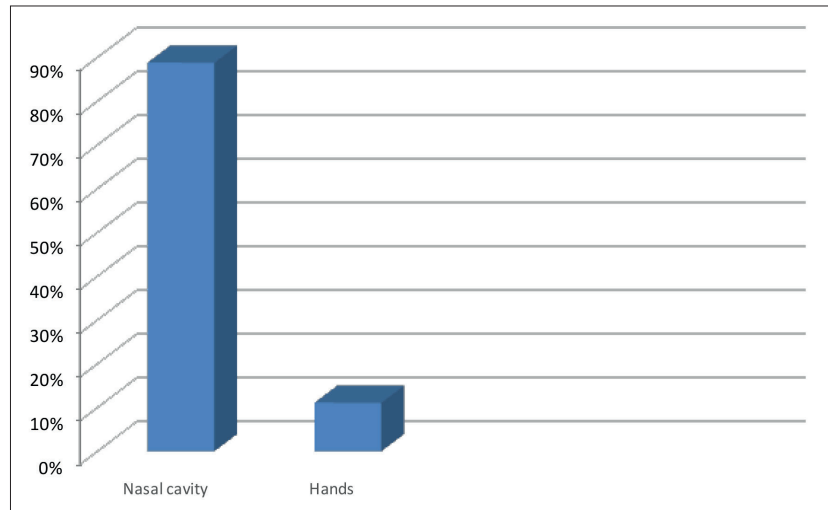


Figure 1. Prevalence of *S. aureus* in the nasal cavities and hands of health professionals in the operating room of a hospital.

Table 2 - Antimicrobial susceptibility profile of *S. aureus* strains isolated from the hands and nasal cavities of health professionals in the operating room of a hospital.

ANTIMICROBIAL	SENSITIVE	EXPANDED SENSITIVITY	RESISTANT
Amikacin 30	31 (86,11%)	2 (5,56%)	3 (8,33%)
Amoxicillin / Clavulanic acid 30	8 (22,22%)	0 (0%)	28 (77,78%)
Ampicillin / Sulbactam 20	8 (22,22%)	0 (0%)	28 (77,78%)
Azithromycin 15	14 (38,89%)	3 (8,33%)	19 (52,78%)
Cefazolin 30	32 (88,89%)	0 (0%)	4 (11,11%)
Cefotaxime 30	32 (88,89%)	0 (0%)	4 (11,11%)
Cefoxitin 30	32 (88,89%)	0 (0%)	4 (11,11%)
Ciprofloxacin 5	35 (97,22%)	0 (0%)	1 (2,78%)
Clindamycin 2	24 (66,67%)	6 (16,67%)	7 (19,44%)
Erythromycin 15	14 (38,89%)	3 (8,33%)	19 (52,78%)
Gentamicin 10	33 (91,67%)	0 (0%)	3 (8,33%)
Nitrofurantoin 300	35 (97,22%)	0 (0%)	1 (2,78%)
Oxacillin 1	32 (88,89%)	0 (0%)	4 (11,11%)
Penicillin G 10	8 (22,22%)	0 (0%)	28 (77,78%)
Rifampicin 5	18 (50%)	8 (22,22%)	10 (27,78%)
Sulfazotrim 25	32 (88,89%)	0 (0%)	4 (11,11%)
Tetracycline 30	22 (61,11%)	9 (25%)	5 (13,89%)

OBS: It is called as sensitive increased exposure (I) when there is a high probability of therapeutic success if the exposure of the drug is increased by adjusting the dosage regimen or its concentration at the site of infection.⁽¹⁷⁾

Table 3 - Antimicrobial susceptibility profile of *MRSA* strains isolated from a surgical center healthcare professional.

Samples Collection	Positive Samples for <i>MRSA</i>	Antimicrobial resistance
Collect 1	N11	PEN, AMC, CFZ, APS, CLI, OXA, RIF, SUT, CTX, CFO
Collect 2	N11 M11	PEN, AMC, CFZ, APS, OXA, RIF, CTX, CFO PEN, AMC, CFZ, APS, CLI, OXA, CTX, CFO
Collect 3	N11	PEN, AMC, CFZ, APS, OXA, CTX, CFO

Antibiotic caption: OXA: oxacillin; PEN: penicillin; AMC: amoxicillin / clavulanic acid; CFZ: cefazolin; APS: ampicillin / sulbactam; RIF: rifampicin; CTX: cefotaxime; CFO: cefoxitin; CLI: clindamycin; SUT: sulfamethoxazole / trimethoprim.

DISCUSSION

Of the 27 professionals, the age ranged from 20 to 50 years, obtaining an average (34.4 years) data similar to a research conducted in northern Ethiopia, where Shibabaw, Abebe, Mihret⁽¹⁴⁾ cite achieve an average age of 30.4 years old, an age group where the majority of the population is already working. On the other hand, the work by Barcudi *et al.*,⁽¹⁹⁾ who compared the circulation of *MRSA* between the community and the hospital environment, obtained an average age of 24 years, a relatively smaller age group compared to the data obtained in our study.

In our study, the majority (59.2%) of the participants were female, corroborating the results of Pathare *et al.*⁽⁷⁾ in which there was also a female predominance (82.6%) among the participants of their research.

The data found in our study are similar to several studies already carried out regarding health professionals with *S. aureus*. Our results (40.7% with *S. aureus* in the nasal cavities) are similar to those found by Pourramezan, Moghadam and Pourmand⁽²⁰⁾ who of 133 participants, 53 (39.8%) had *S. aureus* in the nasal cavities.

The smallest number (14.81%) of *S. aureus* carriers in the hands found in our study was also reported by Castro *et al.*⁽²¹⁾ who claimed to have found a lower percentage (8.9%) of strains of *S. aureus* in the hands compared to the nostrils (39.6%), corroborating to the hypothesis that a good part of healthcare professionals have a correct hygiene routine, since the hands are not a reflection of the nasal microbiota.

Nasal colonization by *S. aureus* is an important risk factor for the development of infections, because although colonization is generally harmless, the healthcare professional can be considered one of the exogenous sources of infections associated with health care.⁽²²⁾ The research by Moremi *et al.*⁽²³⁾ reports that although the evidence is low, there is a possibility that healthcare professionals are reservoirs of *S. aureus*, for the cross-transmission of this bacteria; a fact that highlights the role of examining them as part of infection control measures hospital, especially during outbreaks.

The antimicrobial susceptibility profiles of *S. aureus* isolated from healthcare professionals revealed that 77.78% of the strains were resistant to the antibiotics penicillin, amoxicillin / clavulanic acid and ampicillin / sulbactam, these results being similar to a study conducted in a hospital in Ghana by Walana *et al.*⁽²⁴⁾ who reported 81.5% of strains resistant to amoxicillin. Furthermore, Chinnamedu *et al.*,⁽¹¹⁾ demonstrated that a large number of strains (95.2%) were resistant to penicillin.

These resistance found for the aforementioned antibiotics can be explained by the fact that these antimicrobials are frequently used to treat common infections in the clinical routine in health centers and hospitals, causing concern regarding the high percentage of resistant strains,

mainly because *S. aureus* it is one of the most common microorganisms involved in nosocomial infections.

The high sensitivity (97.22% of the strains) to the antimicrobials nitrofurantoin and ciprofloxacin are similar to the results found by Chinnamedu *et al.*,⁽¹¹⁾ in southern India, who also found that the antibiotic nitrofurantoin was the one with the lowest level of resistance, thus concluding that the classes of nitrofurans and quinolones are highly sensitive to the strains of *S. aureus* tested.

The multidrug resistance (58.3%) found in the strains isolated in this study has been one of the main concerns and discussions, as many studies report this problem faced by healthcare professionals.

Especially the multidrug resistance of *S. aureus* strains has been observed for many years. In the work carried out by Nur *et al.*,⁽²⁵⁾ still in 1997, 26% of multidrug-resistant strains were diagnosed. Recently, Walana *et al.*⁽²⁴⁾ reported that 18.5% of *S. aureus* were multidrug-resistant.

This information causes concern, since in a hospital environment, patients are immunocompromised, receiving high doses of drugs that sometimes have side effects, weakening them even more, which makes them a target for multi-resistant bacteria and few therapeutic options, as well as being able to cause outbreaks of infections.

According to Walana *et al.*⁽²⁴⁾ as antibiotics are widely used in health facilities, professionals who work in these places are generally colonized by multidrug-resistant strains and the *S. aureus* infections resulting from these people are difficult to treat.

Another clinically important challenge associated with *S. aureus* is the development of strains resistant to methicillin / oxacillin which are most often resistant to other antibiotics as well.

In our work we found a low number (only one professional) of people with *MRSA*. Some articles also report the low prevalence of this microorganism, such as the study conducted by Rao, Nayak and Prasad,⁽²⁶⁾ with 3.7% of *MRSA* carriers. On the other hand, it is common to find other studies in the literature that demonstrate a higher prevalence of this bacteria in healthcare professionals such as Safdari *et al.*,⁽²⁷⁾ who reported the prevalence of *MRSA* in 31% of professionals.

The prevalence rate (11.11%) of *MRSA* in our research is similar to the studies by Pathare *et al.*⁽⁸⁾ and Buenaventura-alcazaren *et al.*⁽²⁸⁾ who reported prevalence of *MRSA* in healthcare professionals of 15.1% and 13% respectively.

Periodic screening of caregivers and healthcare professionals to identify carriers is essential to prevent hospital infections associated with *MRSA* in a healthcare setting. In Brazil, several studies have demonstrated a prevalence of *S. aureus* infections acquired in hospitals, ranging from 17% to 26%, and approximately 70% to 100% of these infections are caused by multi-resistant strains.⁽²⁹⁾

Therefore, as infections resulting from these *MRSA* strains are difficult to treat, the resulting effects include prolonged hospitalization and increased healthcare costs.⁽³⁰⁾ For this reason, the ecological niche and the virulence nature of *S. aureus*, together with the growing concerns about antibiotic resistance, could justify the need for healthcare centers to monitor the nasal transport rate of their staff, patients and caregivers, in order to avoid possible sources of outbreaks associated with *S. aureus*.

CONCLUSION

The results found in this research allow us to conclude that healthcare professionals may be carriers of multiresistant *S. aureus* and that the nasal cavity still is one of the main sites colonized by this bacterium. The low rate of *S. aureus* isolated from the hands may be an indicative that the professionals at this hospital have a correct hand hygiene routine.

Besides that, we can conclude that the resistance of *S. aureus* strains to the antimicrobials penicillin, amoxicillin / clavulanic acid and ampicillin / sulbactam may be related to the frequent use of this class of antimicrobials in the treatment of infections.

In this study, were isolated strains of *MRSA* only from one professional, which becomes an important result, since *MRSA* is the main microorganism responsible for infections in the hospital environment and *MRSA* infections are a problem of clinical and public health importance.

Thus, it is suggested that safety regulations with the patient and hygiene protocols should be followed by all professionals, including those without *S. aureus*, since it is extremely important to prevent the spread and promote prevention and control of infections, ensuring greater safety for patients and hospital professionals.

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Resumo

Staphylococcus aureus multirresistente tem sido frequentemente encontrado nas mãos e cavidades nasais de seres humanos, sendo uma das principais causas de infecção nosocomial. O objetivo deste trabalho foi verificar a presença de *S. aureus* nesses sítios anatômicos em 27 profissionais de saúde que trabalham em centro cirúrgico. As amostras foram obtidas por swabs estéreis, previamente humedecidos com solução salina, que posteriormente foram semeados em placas de Petri contendo ágar manitol salgado.

As colônias com aspecto característico foram coradas pelo Gram e submetidas a testes bioquímicos para sua confirmação. Provas de susceptibilidade a antimicrobianos foram também realizadas, utilizando a técnica de difusão em disco descrita por Kirby-Bauer. 40,7% (11) dos profissionais apresentam *S. aureus* nas cavidades nasais e 14,81% (4) apresentaram esse microrganismo nas mãos, pelo menos, em uma das coletas. Das 36 cepas de *S. aureus* isoladas, 11,11% apresentaram resistência à metilina, 77,8% apresentaram resistência à penicilina, amoxicilina/ácido clavulânico e ampicilina/sulbactam e 58,3% se mostraram multirresistentes. A sensibilidade das cepas foi observada principalmente para ciprofloxacina (97,22%) e nitrofurantoína (97,22%). A partir dos resultados encontrados é possível concluir que o número de portadores de *S. aureus* é relativamente alto e que as cepas isoladas são resistentes a múltiplas drogas, principalmente àquelas de primeira escolha, empregadas para controlar infecções comuns.

Palavras-Chave

Staphylococcus aureus, Profissional de Saúde, Resistência a antimicrobianos, infecção hospitalar

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