

Colonization of *Staphylococcus aureus* in nasal cavities of food handlers in a military setting^a

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ABSTRACT

Aims: The anterior nares constitute the primary ecological reservoir for *Staphylococcus aureus* (*S. aureus*) in healthy individuals, with hands serving as the principal vectors for transmission. This study aimed to determine the prevalence of nasal *S. aureus* carriage and evaluate occupational risk factors among military personnel employed in food handling, personal care, and service delivery roles.

Methods: A retrospective analytical cross-sectional study was conducted on 1,036 healthy male service personnel who presented to family medicine outpatient clinics in Ankara. Nasal swabs were cultured for *S. aureus*, and isolates were classified as methicillin-susceptible (MSSA) or methicillin resistant (MRSA). Demographic variables and occupational sectors (service personnel, food preparation, and personal care) were recorded. Positive carriers received targeted topical antimicrobial treatment. Statistical analyses were performed using IBM SPSS v25.0, with significance defined as $p < 0.05$. Chi-square tests were utilized to assess associations, and 95% confidence intervals (CI) were provided for prevalence rates and odds ratios.

Results: The cohort median age was 21 years (IQR=4.0). Overall nasal colonization with *S. aureus* was 15.1% (n=156). MSSA prevalence was 14.1% (n=146) while MRSA was identified in 1.0% (n=10) of the sample, exclusively among catering personnel. Occupational sector was a significant predictor of nasal carriage ($\chi^2=22.635$, $p < 0.001$), with service delivery staff exhibiting increased odds of colonization (OR=3.307, 95% CI: 2.152-5.081).

Conclusion: In this military cohort, moderate *S. aureus* colonization contrasted with infrequent MRSA carriage. However, the elevated risk in specific sectors necessitates targeted infection control. Despite debates over universal screening, these findings justify continued surveillance and decolonization for specialized military food service personnel to mitigate transmission and safeguard public health.

Keywords: *Staphylococcus aureus*, nasal colonization, military personnel, food handler, MRSA, MSSA

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INTRODUCTION

Staphylococcus aureus (*S. aureus*) is the most common potentially pathogenic bacteria that may asymptotically colonize and lead to carriage in many sites of healthy individuals. While several factors contributing to nasal carriage of *S. aureus* have been identified, it is clear that host-related determinants alone are insufficient to explain the observed inter-individual variations.¹ The nasal cavity is the primary ecological niche for *S. aureus*, thus positioning it as a key site for potential transmission. A number of risk factors have been identified in relation to nasal carriage of *S. aureus*, including male gender, advanced age, alcohol consumption, diabetes mellitus, atopic dermatitis, HIV seropositivity,

hospitalization, surgery, antibiotic use, and certain occupations, such as healthcare workers and veterinarians.¹⁻³ Collective living environments (e.g. military institutions, kindergartens, dormitories) are considered risk factors for nasal carriage and human-to-human transmission.¹⁻³ Durupt et al.⁴ also state that skin conditions like furuncles and impetigo are significant risk factors for recurrent nasal colonization, affecting approximately 60% of those affected.

S. aureus is a cause for concern due to its virulence factors, which cause uncomplicated skin infections and more severe pathologies, such as osteomyelitis and endocarditis.⁵⁻⁷

Approximately 30% of the population has *S. aureus* in their nose, which can lead to more serious infections.⁸ There is also a higher rate of *Staphylococcus* in adults, particularly among hospitalized adults.⁹ It is important to note that nasal decolonization of *S. aureus* is recognised as an effective strategy for preventing invasive infections, particularly when performed prior to surgery.^{10,11} While detection and eradication of the bacterium can be beneficial for persistent carriers this approach may not be suitable for healthy populations. MRSA can lead to food contamination and poisoning, so food handlers should be screened before employment and regularly during their tenure.¹² Anterior nasal swab sampling is considered practical and cost-effective for detecting *S. aureus* colonization. However, while real-time polymerase chain reaction (PCR) for MRSA in nasal swabs is considered a reliable diagnostic tool, the WHO has concluded that preemployment medical examinations and periodic screenings are often unnecessary in general civilian settings.^{13,14} Studies suggest that health status influences *S. aureus* nasal bacteria composition.^{15,16} However, data on *S. aureus* nasal colonization in healthy workers is limited.^{17,18} A baseline is crucial for studying community colonization. This analytical cross-sectional study assessed *S. aureus* carriage in the nares of healthy food handlers in a military setting, focusing specifically on occupational sectors and age as potential determinants.

METHODS

Ethics

This study was approved by the Ethics Committee of Dışkapı Yıldırım Beyazıt Training and Researches Hospital, University of Health Sciences (Date: 10.09.2018, Decision No: 54/21). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design and Population

This retrospective analytical cross-sectional study was performed to isolate and characterize *S. aureus* isolates. The population consisted of military personnel who presented at the Family Medicine Outpatient Clinic of Ankara Etlik City Hospital for bacterial carrier screening. Of the 1,656 participants who were examined over a period of six months, 1,036 individuals were included in the study as they met the following inclusion criteria: the absence of any known chronic disease, no history of hospitalization within the past month, and no current upper respiratory tract infection at the time of swab collection. All participants were employed in the food, personal care, or service delivery sectors within military units in Ankara, and some were employment applicants.

Isolation and Characterization of *S. aureus*

S. aureus carriage was assessed by swabs taken from the anterior nares. The medical records of all participants were included in the national carrier examination procedure: physical examination, X-ray findings, stool culture, and nasal swab screening. Only the nasal isolate results were evaluated in the present study. The bacterial samples were collected from the participants' anterior nasal mucosa using sterile cotton-tipped swabs with transport media. The blood agar was inoculated using the laboratory reduction method. The samples were incubated at 35-37°C for 16 to 24 hours, after which colony growth was assessed by microbiologists.

In this study, *S. aureus* strain ATCC 33862 was used as the reference strain. The isolates were identified based on colony morphology, Gram stain appearance, and positivity for catalase and coagulase tests. Creamy-yellow, beta-hemolytic colonies were considered "suspect *S. aureus*." Gram-positive colonies with positive catalase and coagulase tests were identified as *S. aureus*. Methicillin resistance was tested using Mueller-Hinton agar (Biomérieux, France) with a cefoxitin disk. A 30 µg cefoxitin disk (Oxoid) was placed on the medium and incubated at 35°C for 24 hours. Colonies with a zone diameter ≤21 mm were considered methicillin-resistant. Antibiotics tested included erythromycin, clindamycin, gentamicin, vancomycin, teicoplanin, and trimethoprim-sulfamethoxazole (Oxoid). All results were analyzed according to EUCAST guidelines.

A retrospective review of the culture results of nasal isolates obtained by this method was conducted over a six-month period. The results were categorized into normal and pathogenic (MRSA and MSSA) groups. The normal bacterial flora included *Streptococcus*, *Corynebacterium*, *Propionibacterium*, *Acinetobacter*, and others. Participants (n=156) with pathogenic bacterial growth on the initial nasal culture were treated topically with mupirocin, and a follow-up nasal culture was performed after 10 days.

Statistical Analysis

The nasal isolates of the staff sector were evaluated using frequency and percentage values. As the data did not follow a normal distribution, the descriptive statistics of the age variable were presented as median (interquartile range). The differences between the categorical variables were examined using the Chi-square test and Fisher's exact test when indicated. The 95% confidence intervals (CI) for prevalence rates and ratios were calculated. A p-value<0.05 was deemed significant, and values below 0.001 were reported as p<0.001. All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.

RESULTS

The study cohort comprised 1,036 healthy male participants, with a mean (±SD) age of 24.1 (±6.8) years and a median age of 21 years (range: 19–55). The vast majority (n=948, 91.5%) consisted of service delivery personnel stationed within military dining facilities, including restaurants, cafés, and canteens. Microbiological analysis revealed that 880 participants (84.9%, 95% CI: 82.7-87.1) exhibited only commensal nasal microflora and were consequently classified as uncolonized. Regarding pathogenic isolates, methicillin-sensitive *S. aureus* (MSSA) was identified in 146 individuals (14.1%, 95% CI: 12.0-16.2), whereas methicillin-resistant *S. aureus* (MRSA) was detected in a small proportion of the sample (n=10, 1.0%, 95% CI: 0.4-1.6) (Figure). MSSA prevalence was notably higher among food preparation staff (16.7%) and catering personnel (14.1%), groups identified as having more direct contact with food (Table 1). Statistical evaluation across four age-defined subgroups demonstrated no significant discrepancy in colonization rates (Kruskal-Wallis: 1.561, p=0.458) (Table 2). Participants harboring pathogenic nasal isolates underwent a five-day therapeutic regimen of topical mupirocin. Subsequent follow-up cultures yielded negative results for all pathogens, confirming the successful eradication of carriage.

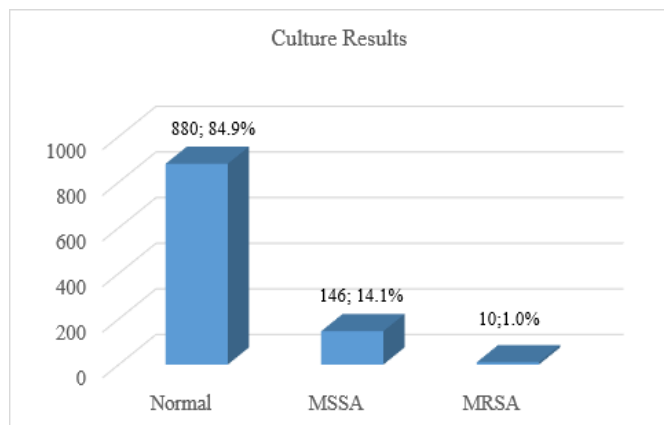


Figure. Number of cases with nasal carriage

MSSA: Methicillin-susceptible *Staphylococcus aureus*, MRSA: Methicillin-resistant *Staphylococcus aureus*

was on average 16.78% in China.¹⁸ In this study, it was determined that the carrier rate was lower than in studies conducted on comparable sample groups. This discrepancy can be attributed to the implementation of pre-employment carrier screening of food handlers in our country, followed by the continuation of regular annual screening. Additionally, the tightly controlled nature of military environments may have contributed to a lower prevalence compared to other community dwellings.

A study conducted in Beijing reported that the prevalence of *S. aureus* nasal carriage among military personnel ranged from 16.1% to 24.6%. Consistent with our findings, MSSA was the predominant isolate.²³ MRSA bacteremia is associated with significantly higher rates of severe and potentially fatal infections compared to MSSA bacteremia.²⁴ In this study,

Table 1. Prevalence of nasal methicillin-sensitive *Staphylococcus aureus* and methicillin-resistant *S. aureus* (MRSA) carriage among healthy males in military units

Characteristics		Bacterial Colonization			χ^2 ; p*
		Normal n (%)	MSSA n (%)	MRSA n (%)	
Age groups	≤20	256 (85.6)	39 (13.0)	4 (1.3)	3.149; 0.790
	21-30	534 (84.6)	92 (14.6)	5 (0.8)	
	31-40	39 (90.7)	4 (9.3)	0 (0.0)	
	41-55	51 (81.0)	11 (17.5)	1 (1.6)	
Sector	Food preparation	55 (83.3)	11 (16.7)	0 (0.0)	2.971; 0.563
	Hairdresser	21 (95.5)	1 (4.5)	0 (0.0)	
	Catering personnel	804 (84.8)	134 (14.1)	10 (1.1)	
Total		880 (84.9)	146 (14.1)	10 (1.0)	

MSSA: Methicillin-susceptible *Staphylococcus aureus*, MRSA: Methicillin-resistant *Staphylococcus aureus*, χ^2 : Chi-square, *Pearson Chi-square.

Table 2. Distribution of *S. aureus* growth in culture

		Mean (SD) Median (IQR 25-75)	P ^a
Culture result	Normal	24.0 (7.0) 21.0 (20.0-25.0)	
	MSSA*	25.0 (8.0) 21.0 (20.0-25.0)	1.561; 0.458
	MRSA*	24.0 (9.0) 21.0 (20.0-21.0)	

SD: Standard deviation, IQR: Interquartile range, *Kruskal-Wallis, MSSA: Methicillin-sensitive *Staphylococcus aureus*, MRSA: Methicillin-resistant *Staphylococcus aureus*

DISCUSSION

The main result of this study delineates a significant microbiological landscape within the military food-service sector, characterized by a substantial reservoir of MSSA colonization (14.1%) alongside a conspicuously low prevalence of MRSA (1.0%). Our results provide evidence of an MSSA burden among food preparation cohorts, while demonstrating that targeted topical intervention can effectively achieve total eradication of pathogenic carriage. The prevalence of *S. aureus* isolation among workers in military units was found to be 14.1%, a result comparable to those reported in Eastern Ethiopia (15.6%), Nepal (15.7%), and the Democratic Republic of Congo (16.5%).¹⁹⁻²¹ However, a multicentre study across nine European countries reported a global prevalence of *S. aureus* nasopharyngeal colonization at 21.6% and in healthy males in Pakistan at 20.5%.^{17,22} In addition, the prevalence of *S. aureus* nasal carriage among the community individuals

MRSA prevalence was reported at 0.9%, exclusively among individuals working in catering-related professions. This aligns with research from Peru and China documenting low or zero MRSA carriage among military personnel.^{23,25} In contrast, higher MRSA prevalence rates (11.2% to 21.9%) have been reported among healthcare workers. The highest nasal carriage rate was reported among nurses (7.8%).¹⁹⁻²¹ These variations in prevalence may be attributable to differences in geographic regions, sample sizes, study periods, and characteristics of the populations studied. It is worthy of note that studies reporting elevated prevalence frequently focus on individuals with heightened occupational exposure to bacterial colonization, a factor that may account for these results.

The study found that MSSA prevalence was highest in the food preparation department, whereas MRSA was exclusively identified among a small number of individuals employed in catering roles. This suggests a potential role for service departments in military environments regarding food contamination.

While some literature suggests that routine screening of healthy populations may not always yield clinically significant outcomes that are commensurate with the associated economic burden,^{14,26} the specific context of congregate living and food service in military institutions warrants a different approach. Although universal active surveillance in all at-risk groups is debated, the findings of this study support the utility of targeted screening within high-risk

occupational sectors like military food service to prevent potential outbreaks.²⁷ A prospective cohort study involving military personnel indicated that although nasal colonization resulted in a relatively low incidence of self-reported soft-tissue infections (3%), the role of healthy carriers—whether persistent or intermittent—in the horizontal transmission of pathogens to susceptible individuals is well-established.²⁸ Based on these findings, it is rational to include military food service personnel in routine screening and follow-up programs.

Various therapeutic modalities have been employed to prevent permanent colonization, most notably the application of intranasal mupirocin ointment (2%) b.i.d. for a duration of 5–10 days, augmented by daily chlorhexidine body washes. These aim to prevent recurrent skin and soft tissue infections, as well as nosocomial MRSA infections.^{14,29} In the present study, 156 participants with *S. aureus* colonization in nasal culture received local treatment with mupirocin and nasal isolates were repeated after 10 days. Furthermore, as observed by Hirabayashi et al.,³⁰ the prevalence of MRSA in clinical isolates experienced a significant decline during the SARS-CoV-2 pandemic. The observed decline likely reflects the efficacy of the robust prophylactic measures instituted to halt viral spread. This underscores the notion that, even during pandemics, infection control and self-hygiene are key protection methods against *S. aureus*, as with other communicable diseases. These strategies are crucial for reducing infections and strengthening public health within organized institutions.

Limitations

This study assessed *S. aureus* colonization among military food handlers. However, the reliance on a single nasal culture represents a significant methodological constraint, potentially obscuring the true prevalence of both MRSA and MSSA. Furthermore, the retrospective analytical cross-sectional design and the exclusively military sample may limit the generalizability of the results to broader civilian populations. Although the objective of the study was to assess risk factors, only occupational group and age were analyzed, the omission of other potential risk factors has been formally acknowledged as a study limitation.

CONCLUSION

Consequently, the continuation of screening for personnel assigned to provide services in specialized settings, such as military institutions, is deemed appropriate to maintain low colonization rates and prevent transmission. While universal screening in all healthy populations is debated, a targeted and effective surveillance protocol in food-handling sectors provides a rational approach. This strategy optimizes resource management while ensuring effective control measures and optimal health outcomes in high-density living environments.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Ethics Committee of Dışkapı Yıldırım Beyazıt Training and Researches Hospital (Date: 10.09.2018, Decision No: 54/21).

Informed Consent

This retrospective study used pre-existing anonymized patient data. No additional intervention was performed, and there was no direct patient contact. The study was approved by the Ethics Committee, and the requirement for written informed consent was waived by the ethics committee.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The author declare no conflicts of interest related to this study.

Financial Disclosure

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Author Contributions

The author is solely responsible for the conception, data collection, analysis, and writing of this manuscript.

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