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Original article

WORKPLACE AND HOUSEHOLD HYGIENE PRACTICES ASSOCIATED WITH NASAL CARRIAGE OF *STAPHYLOCOCCUS AUREUS* AMONG FOOD HANDLERS IN SKOPJE, NORTH MACEDONIA

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Abstract

Introduction: *Staphylococcus aureus* (*S. aureus*) nasal carriage among food handlers represents a potential source of food contamination and transmission in food-related settings. The aim of this study was to investigate workplace and household hygiene practices and their association with *S. aureus* nasal carriage among food handlers in Skopje, North Macedonia.

Materials and methods: This cross-sectional study was conducted from November 2021 to March 2022 and included 289 workers undergoing mandatory health and sanitary examinations. Data were collected using a structured questionnaire, and nasal carriage was determined by microbiological examination of nasal swabs. Associations between hygiene-related factors and carriage status were evaluated using the chi-squared test.

Results: The overall prevalence of *S. aureus* nasal carriage was 12.5% (36/289). Significant associations were identified between nasal carriage and handwashing before starting work (p=0.004) as well as handwashing frequency during work (p=0.023). Food handlers reporting poorer hand hygiene practices exhibited higher carriage rates. No statistically significant associations were observed between nasal carriage and the availability of hand soap or hand sanitizer, glove use, mask use, work clothing practices, sharing of work equipment, availability of personal lockers, or the household hygiene factors examined.

Conclusion: The findings suggest that hand hygiene practices may play an important role in *S. aureus* colonisation among food handlers, while the contribution of other workplace and household hygiene factors appears limited in this population. Continued promotion of proper handwashing practices remains an important component of food safety and infection prevention.

Keywords: hand hygiene, methicillin-resistant *Staphylococcus aureus*, food safety

Introduction

Staphylococcus aureus (*S. aureus*) is an important public health pathogen commonly associated with both healthcare-associated and community-acquired infections. Nasal colonization represents a major reservoir for transmission and may increase the risk of

subsequent infection in both carriers and their surroundings[1]. Alongside norovirus, hepatitis A virus, *Salmonella*, and *Shigella*, *S. aureus* is among the pathogens most frequently transmitted by food workers[2]. Food handlers carrying *S. aureus* may contribute to contamination of food products and food-contact surfaces through direct hand contact, respiratory droplets, or contact with contaminated clothing and equipment[3]. Food-service workers carrying enterotoxigenic strains may also represent a reservoir for food contamination and staphylococcal food intoxication[4]. Consequently, adequate hygiene measures among food handlers remain important for reducing the risk of contamination and transmission in food-related environments. Previous studies have shown that nasal carriage may be influenced by multiple behavioral, environmental, and hygiene-related factors, including personal hygiene habits, workplace hygiene measures, and household exposures[2,5]. Household environments and shared hygiene practices may also play a role in the transmission of *Staphylococcus aureus* among close contacts[6,7]. Despite the recognized importance of these factors, information on workplace and household hygiene practices and their potential association with *S. aureus* nasal carriage among food handlers remains limited. In the Republic of North Macedonia, employees involved in food production, trade, and distribution undergo mandatory health and sanitary examinations every six months in accordance with national regulations[8]. However, data on workplace and household hygiene practices among food handlers remain scarce. Therefore, the aim of this study was to investigate workplace and household hygiene practices and their association with nasal carriage of *S. aureus* among food handlers in Skopje, North Macedonia.

Materials and methods

This cross-sectional study was conducted at the Institute of Public Health in Skopje, North Macedonia, between November 2021 and March 2022 during mandatory health and sanitary examinations of workers employed in food production, distribution, and trade. The study population represented a range of occupational categories within the food sector, including cooks, bakers and assistant cooks, distributors, quality control personnel, storekeepers, packagers, salespersons, production workers, catering staff, cleaners, and other workers. Participation in the study was voluntary, and a total of 289 workers (140 men and 149 women) agreed to participate, completed the questionnaire, and provided written informed consent. Data collection included microbiological testing and a structured questionnaire. A single nasal swab was obtained from each participant and processed using standard microbiological procedures. Presumptive *Staphylococcus aureus* isolates were identified based on colony morphology, Gram staining, catalase testing, and DNase activity. Methicillin resistance was determined phenotypically using the cefoxitin disc diffusion method and interpreted according to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines. A detailed description of the microbiological procedures has been published previously[9].

The questionnaire was adapted from a previously published hygiene behavior scale[10] to address the specific objectives of the present study. The adaptation involved retaining selected original items, modifying others to suit the study context, omitting questions that were not relevant, and incorporating additional study-specific questions. The resulting questionnaire included items on sociodemographic characteristics, health status, social activities, personal hygiene practices, workplace hygiene habits, and household hygiene characteristics. The sections concerning general demographic characteristics and health status were completed with the assistance of a physician, whereas the sections related to social activities, hygiene practices, work habits, and household hygiene were self-completed by the participants. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), version 16.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant characteristics and questionnaire responses. Participants were categorized according to nasal

carriage status as positive for *Staphylococcus aureus* (including MRSA) or negative for *Staphylococcus aureus*. Associations between carriage status and demographic characteristics, health conditions, social activities, personal hygiene practices, workplace hygiene habits, and household hygiene factors were assessed using the chi-squared test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 289 food handlers were included in the analysis, of whom 36(12.5%) were identified as carriers of *S. aureus*, including methicillin-resistant *Staphylococcus aureus* (MRSA), while 253(87.5%) were without the pathogen.

Table 1. Workplace hygiene practices among food handlers

Variable	Category	Nasal carriers n (%)	Without pathogen n (%)	Total	Chi-square	df	p
Hand washing before starting shift	Yes	26(10.5)	222(89.5)	248	10.844	2	0.004
	No	10(29.4)	24(70.6)	34			
	Sometimes	0(0.0)	7(100.0)	7			
Availability of hand soap at workplace	Yes	35(12.6)	242(87.4)	277	0.348	2	0.840
	No	0(0.0)	2(100.0)	2			
	Sometimes	1(10.0)	9(90.0)	10			
Availability of hand sanitizer at workplace	Yes	34(12.5)	237(87.5)	271	0.533	2	0.766
	No	1(20.0)	4(80.0)	5			
	Sometimes	1(7.7)	12(92.3)	13			
Glove use at workplace	Yes	20(10.9)	163(89.1)	183	1.068	2	0.586
	No	5(15.2)	28(84.8)	33			
	Sometimes	11(15.1)	62(84.9)	73			
Mask use at workplace	Yes	25(10.8)	207(89.2)	232	3.125	2	0.210
	No	8(18.6)	35(81.4)	43			
	Sometimes	3(21.4)	11(78.6)	14			
Use of work clothes outside workplace	Yes	2(25.0)	6(75.0)	8	1.322	2	0.516
	No	34(12.1)	246(87.9)	280			
	I do not have	0(0.0)	1(100.0)	1			
Sharing work equipment with colleagues	Yes	2(8.7)	21(91.3)	23	0.475	2	0.789
	No	34(12.8)	231(87.2)	265			
	I do not have	0(0.0)	1(100.0)	1			
Own locker for storing work clothes	Yes	27(11.1)	217(88.9)	244	3.156	2	0.206
	No	9(20.5)	35(79.5)	44			
	There is no uniform and no need for a locker	0(0.0)	1(100.0)	1			
Hand washing frequency at work	≤3 times/day	13(13.4)	84(86.6)	97	7.519	2	0.023
	4–5 times/day	19(17.8)	88(82.2)	107			
	≥6 times/day	4(4.7)	81(95.3)	85			

Workplace hygiene practices among food handlers are presented in Table 1. A statistically significant association with nasal carriage was observed only for hand washing before starting the work shift (p=0.004). Participants who reported not washing their hands before starting work showed a higher prevalence of nasal carriage compared to those who reported washing their hands before beginning their shift. No statistically significant associations were observed between nasal carriage and the availability of hand soap or hand sanitizer at the workplace, glove use, mask use, use of work clothes outside the workplace, sharing work equipment with colleagues, availability of a personal locker for work clothes, or hand-washing frequency at work (Table 1).

Table 2. Household characteristics and hygiene practices among food handlers

Variable	Category	Nasal carriers n (%)	Without pathogen n (%)	Total	Chi-square	df	p
Household member working in a healthcare facility	Yes	1(3.3)	29(96.7)	30	2.555	1	0.110
	No	35(13.5)	224(86.5)	259			
Sharing clothes, including underwear, with family members	Yes	1(5.6)	17(94.4)	18	0.838	1	0.360
	No	35(12.9)	236(87.1)	271			
Sharing a handkerchief to wipe hands with household members	Yes	12(12.5)	84(87.5)	96	0.000	1	0.987
	No	24(12.4)	169(87.6)	193			
Drinking from the same glass by all family members	Yes	3(10.3)	26(89.7)	29	0.696	2	0.706
	No	32(12.5)	224(87.5)	256			
	Sometimes	1(25.0)	3(75.0)	4			
Having a pet in the household	Yes	7(13.5)	45(86.5)	52	0.059	1	0.809
	No	29(12.2)	208(87.8)	237			
Type of soap used for handwashing	Bar soap	2(5.1)	37(94.9)	39	2.356	2	0.308
	Liquid soap	27(13.2)	177(86.8)	204			
	Combined	7(15.2)	39(84.8)	46			

Household characteristics and hygiene practices are presented in Table 2. No statistically significant associations were identified between nasal carriage and having a household member employed in a healthcare facility, sharing clothes or handkerchiefs with family members, drinking from the same glass, pet ownership, or the type of soap used for handwashing (Table 2).

Discussion

The principal finding of the present study was the association between hand hygiene practices and *S. aureus* nasal carriage among food handlers. Of the workplace and household hygiene factors investigated, significant associations with carriage status were identified only for handwashing before starting work and handwashing frequency during work.

Hand hygiene is widely recognized as one of the most effective measures for preventing the transmission of microorganisms in food-handling environments. Pathogens originating from the nose, throat, skin, and gastrointestinal tract are frequently transmitted through contaminated hands, emphasizing the importance of proper handwashing practices among food handlers[11]. Previous studies from North Macedonia have likewise identified suboptimal hand hygiene practices among workers[12]. Our findings support the hypothesis that inadequate hand hygiene may facilitate the persistence and spread of *S. aureus* within food preparation environments. Similar observations have been reported previously, and enhanced hygiene measures have been associated with reductions in both nasal and hand carriage of *S. aureus* among food handlers[2]. Environmental contamination by persistently colonized individuals may further facilitate indirect transmission through contaminated surfaces and shared work environments, underscoring the importance of regular handwashing and compliance with hygiene measures.

In contrast to the significant associations observed for hand hygiene practices, no statistically significant associations were identified between nasal carriage of *S. aureus* and other workplace hygiene measures, including the availability of hand soap or hand sanitizer, glove use, mask use, work clothing practices, sharing of work equipment, and the availability of personal lockers. Similar workplace hygiene measures have previously been associated with reduced contamination and lower carriage rates among food handlers and other occupational groups[2,13]. However, the available evidence remains inconsistent, and the absence of significant associations between hygiene-related practices and *S. aureus* carriage has also been reported among food handlers[4]. This observation may reflect the multifactorial nature of *S. aureus* colonization, which is influenced not only by workplace hygiene measures but also by

personal hygiene habits, workplace environment, hygiene of equipment and utensils, and other host-related factors[14]. Accordingly, workplace hygiene measures, although important for food safety and contamination control, may not represent independent determinants of nasal carriage among food handlers.

Household transmission has been recognized as an important component of *S. aureus* epidemiology. Increased colonization risks have been reported among household contacts of carriers, while sharing personal hygiene items and close contact within households may facilitate the dissemination of *S. aureus* strains[6,7,15]. In addition, household pets have been identified as potential reservoirs of S. aureus, although their contribution to human colonization appears limited[7,16]. In contrast, no statistically significant associations were identified in the present study between nasal carriage and the presence of healthcare workers in the household, sharing clothes or handkerchiefs, drinking from the same glass, pet ownership, or the type of soap used for handwashing. A recent prospective cohort study reported infrequent household transmission of *S. aureus*, suggesting that household exposures may not represent the predominant determinants of colonization in all populations[17]. Taken together, these findings indicate that the contribution of household factors to nasal carriage may vary according to local epidemiological, behavioral, and environmental circumstances.

This study has several limitations. First, its cross-sectional design does not allow causal relationships between hygiene practices and nasal carriage of *S. aureus* to be established. Second, nasal carriage status was determined using a single nasal swab, which did not allow differentiation between persistent and intermittent carriers. Third, information on workplace and household hygiene practices was obtained through self-reported questionnaires and may therefore be subject to recall bias or socially desirable responses. Despite these limitations, the study contributes to the limited body of evidence on workplace and household hygiene practices and *S. aureus* nasal carriage among food handlers in North Macedonia.

Conclusions

Our study demonstrated significant associations between *S. aureus* nasal carriage and handwashing before starting work as well as handwashing frequency during work among food handlers. No significant associations were identified for the other workplace and household hygiene factors examined. However, these findings should be interpreted with caution in light of the cross-sectional study design and the use of a single nasal swab for carriage assessment. Nevertheless, the results highlight the importance of proper hand hygiene practices among food handlers and support the continued implementation of hygiene measures aimed at reducing colonisation and the potential transmission of *S. aureus* in food-related settings.

Conflict of interest statement. None declared.

References

1. Sivaraman K, Venkataraman N, Cole AM. *Staphylococcus aureus* nasal carriage and its contributing factors. *Future Microbiol* 2009; 4(8): 999-1008. doi: 10.2217/fmb.09.79.
2. Ho J, Boost MV, O'Donoghue MM. Tracking sources of *Staphylococcus aureus* hand contamination in food handlers by spa typing. *Am J Infect Control* 2015; 43(7): 759-761. doi: 10.1016/j.ajic.2015.03.022.
3. Al-Bahry SN, Mahmoud IY, Al-Musharafi SK, Sivakumar N. *Staphylococcus aureus* contamination during food preparation, processing and handling. *Int J Chem Eng Appl* 2014; 5(5): 388. doi: 10.7763/IJCEA.2014.V5.415.
4. Akinnola OO, Williams AN, Oniha MI, Ogunleye BO. Nasal carriage of *Staphylococcus aureus* and associated risk factors among food handlers in a Nigerian university. *J Pure Appl Microbiol* 2022; 16(4): 2507-2513. doi: 10.22207/JPAM.16.4.10.

5. Septimus EJ, Schweizer ML. Decolonization in prevention of health care-associated infections. *Clin Microbiol Rev* 2016; 29(2): 201-222. doi: 10.1128/cmr.00049-15.
6. Yan X, Song Y, Yu X, Tao X, Yan J, Luo F, *et al*. Factors associated with *Staphylococcus aureus* nasal carriage among healthy people in Northern China. *Clin Microbiol Infect* 2015; 21(2): 157-162. doi: 10.1016/j.cmi.2014.08.023.
7. Kao CM, Fritz SA. Infection prevention-how can we prevent transmission of community-onset methicillin-resistant *Staphylococcus aureus*? *Clin Microbiol Infect* 2025; 31(2): 166-172. doi: 10.1016/j.cmi.2024.01.004.
8. Rulebook on the method of performance, content of examinations, types of examinations and deadlines for the performance of mandatory health and hygiene examinations of employees. Official Gazette of the Republic of Macedonia. 2007; (152); 2008; (8). [Internet]. Available from:https://www.slvesnik.com.mk/Issues/DBF60340F47F994D9BD6655016667B29.pdf.
9. Bukovetz J, Todorovski J, Zendeli G, Mijakoski D, Kočubovski M, Kotevska V, *et al*. *Staphylococcus aureus* in the nose and hygiene habits among food handlers in Skopje, North Macedonia. doi: 10.2478/aiht-2026-77-4035.
10. Stevenson RJ, Case TI, Hodgson D, Porzig-Drummond R, Barouei J, Oaten MJ. A scale for measuring hygiene behavior: development, reliability and validity. *Am J Infect Control* 2009; 37(7): 557-564. doi: 10.1016/j.ajic.2009.01.003.
11. Todd EC, Greig JD, Bartleson CA, Michaels BS. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 4. Infective doses and pathogen carriage. *J Food Prot* 2008; 71(11): 2339-2373. doi:10.4315/0362-028X-71.11.2339.
12. Bukovetz J, Kochubovski M, Memeti S, Ristovska G. Preventive measures and hygiene habits of apple producers in the Prespa region. *Indian J Occup Environ Med* 2023; 27(3): 214-218. doi: 10.4103/ijoem.ijoem_47_22.
13. Çakıcı N, Demirel Zorba NN, Akçalı A. Carriage of enterotoxigenic *Staphylococcus aureus* and hygiene practices of food workers. *J Basic Clin Health Sci* 2023;7(2): 618-627. doi: 10.30621/jbachs.1137869.
14. Šegalo S, Maestro D, Obradović Z, Jogunčić A. Nasal carriage rate and antimicrobial resistance pattern of *Staphylococcus aureus* among the food handlers in Canton Sarajevo, Bosnia and Herzegovina. *J Health Sci* 2020; 10(2): 139-146. doi: 10.17532/jhsci.2020.882.
15. Weldegebreal F, Urgesa K, Ayele F, Bogale K, Shume T, Ahmed M, *et al*. Nasal carriage rate, associated factors, and antimicrobial susceptibility patterns of methicillin resistance Staphylococcus aureus among pre-clinical undergraduate students at the College of Health and Medical Sciences, Haramaya University, Ethiopia. *Front Public Health* 2024; 12: 1354461. doi: 0.3389/fpubh.2024.1354461.
16. Musa MD. Prevalence and risk factors for Staphylococcus aureus nasal carriage in healthy companion animals in Al-Nasiriyah, Iraq. *J Bacteriol Virol* 2024; 54(4): 355-366. doi: 10.4167/jbv.2024.54.4.355.
17. Locke T, Siribaddana S, Jayaweera JAAS, Suligoy CM, de Silva TI, Corrigan RM, *et al*. A prospective cohort study to investigate the transmission and burden of Staphylococcus aureus in Sri Lanka. *Microb Genom* 2024; 10(12): 001336. doi: 10.1099/mgen.0.001336.