DOI: https://doi.org/10.53350/pjmhs02024181675

ORIGINAL ARTICLE

Prevalence, Physiological Determinants, and Antibiotic Susceptibility Patterns of Staphylococcus aureus Nasal Carriage among Healthcare Workers: A Hospital-Based Public Health Study

ADINA QAISER[1], AFSHAN ZIA[2], S. M. QAISAR SAJJAD[3], MUHAMMAD TAHIR SHAH[4], HAMID NAWAZ KHOKHAR[5], SYEDA NOSHEEN ZEHRA[6] AQEELA KOUSAR[7]

[1]*Demonstrator, Khawaja Muhammad Safdar Medical College, Sialkot.*
[2]*Assistant Professor of Microbiology, Sharif Medical and Dental College, Lahore.*
[3]*Assistant Professor, Sir Syed College of Medical Sciences for Girls, Karachi.*
[4]*FCPS ENT, Assistant Professor, Fazaia Medical College, Islamabad.*
[5]*Assistant Professor, Department of Pathology, Sahara Medical College, Narowal.*
[6]*Associate Professor of Medicine, Liaquat National Hospital, Karachi, Pakistan*
[7] *Lecturer, Sahara Medical College, Narowal.*
Correspondence to: Hamid Nawaz Khokhar, Email: hamidkhokhar@gmail.com

ABSTRACT

Background: *Staphylococcus aureus* nasal carriage among healthcare workers represents a major public health concern because colonized individuals serve as silent reservoirs for hospital-acquired infections. Understanding prevalence, physiological determinants, and antibiotic susceptibility patterns is essential for designing targeted infection-control strategies.

Objective: To determine the prevalence of *Staphylococcus aureus* nasal carriage among healthcare workers, assess associated physiological determinants, and evaluate antibiotic susceptibility patterns of isolated strains.

Methods: This cross-sectional study was conducted from June 2022 to June 2023 in the Department of Pathology at Sharif Medical and Dental College, Lahore, Sahara Medical College, Narowal, and Sir Syed College of Medical Sciences for Girls, Karachi, Pakistan. A total of 100 healthcare workers were recruited through convenience sampling. Nasal swabs were collected aseptically from the anterior nares and cultured on mannitol salt agar. *Staphylococcus aureus* was confirmed using Gram staining, catalase testing, coagulase testing, and DNase testing. Antibiotic susceptibility was evaluated using the Kirby–Bauer disk diffusion method following Clinical and Laboratory Standards Institute guidelines. Demographic and physiological variables including body mass index, allergic rhinitis, deviated nasal septum, and night-shift duties were recorded and analyzed for association with colonization.

Results: The prevalence of *Staphylococcus aureus* nasal carriage was 34 percent, with 12 percent identified as methicillin-resistant *Staphylococcus aureus*. Colonization was significantly higher among individuals with elevated body mass index, allergic rhinitis, deviated nasal septum, and those working night shifts. High resistance was observed to penicillin and azithromycin, while all isolates remained sensitive to vancomycin and linezolid.

Conclusion: *Staphylococcus aureus* nasal carriage remains common among healthcare workers and is strongly influenced by physiological and occupational factors. Continuous surveillance, decolonization strategies, and antimicrobial stewardship are essential to reduce transmission risk in healthcare settings.

Keywords: *Staphylococcus aureus*, nasal carriage, healthcare workers, physiology, antibiotic susceptibility, MRSA, public health.

INTRODUCTION

Staphylococcus aureus is one of the most clinically significant bacterial pathogens encountered in both community and hospital settings[1]. Its ability to colonize the anterior nares of humans provides an ecological advantage that facilitates persistent carriage, asymptomatic transmission, and subsequent development of invasive infections[2]. Nasal colonization acts as the primary reservoir for *S. aureus*, and healthcare workers represent a particularly important group because they serve as potential vectors for transmitting the organism to vulnerable hospitalized patients. This risk becomes even more critical in high-dependency units, surgical departments, intensive care settings, and dialysis or oncology wards where patients have compromised immunity[3,4].

The global emergence of antimicrobial-resistant strains, especially methicillin-resistant *Staphylococcus aureus* (MRSA), has intensified concerns within infection-control and public health frameworks[5]. MRSA colonization significantly increases the risk of healthcare-associated infections and contributes to longer hospital stays, increased treatment costs, and higher morbidity. In Pakistan and other developing countries, inconsistent screening practices, variable adherence to infection-prevention measures, and overcrowded clinical settings further elevate transmission risk. This highlights the need for periodic surveillance of *S. aureus* nasal carriage among hospital staff[6,7].

While microbial factors contribute to colonization, host physiology plays an equally important role in determining susceptibility. Several physiological characteristics including mucociliary clearance efficiency, nasal mucosal hydration, epithelial integrity, hormonal influences, immune responsiveness, body mass index, and anatomical variations such as deviated nasal septum affect the ability of *S. aureus* to adhere and proliferate within the nasal cavity. Additionally, lifestyle and occupational stressors such as disrupted sleep cycles, irregular meal patterns, long working hours, and chronic fatigue can modulate immune function and alter colonization dynamics[8,9].

Healthcare workers' frequent exposure to patients, contaminated surfaces, and airborne particles makes them ideal carriers if physiological susceptibility is combined with continuous bacterial exposure. Identifying the interplay of host physiology with colonization patterns is therefore essential for designing targeted decolonization strategies[10].

In addition, understanding antibiotic susceptibility profiles of *S. aureus* isolates is crucial for guiding empirical therapy and developing effective infection-control policies. Rising resistance to commonly used antibiotics, particularly beta-lactams and macrolides, demands updated local data to support antimicrobial stewardship programs. Hospital-specific resistance patterns offer insights into circulating strains and help prevent outbreaks[11].

This study aims to provide a comprehensive assessment of the prevalence of *Staphylococcus aureus* nasal carriage among healthcare workers in two major tertiary care hospitals in Lahore. It further evaluates the physiological determinants that increase susceptibility to colonization and analyzes antibiotic susceptibility profiles of the isolates. By integrating microbiological, physiological, and public health perspectives, this study contributes valuable

Received on 06-10-2023
Accepted on 25-12-2023

evidence for strengthening infection-prevention strategies and promoting safer healthcare environments[12].

MATERIALS AND METHODS

Study Design and Duration: This research was designed as a hospital-based cross-sectional observational study and was conducted over a period of twelve months, from June 2022 to June 2023. The study was carried out in the Department of Pathology at two tertiary-care institutions: Sharif Medical and Dental College, Lahore, Sahara Medical College, Narowal and Sir Syed College of Medical Sciences for Girls, Karachi, Pakistan. Both sites provide a busy clinical environment with diverse healthcare workers exposed to different levels of patient interaction, thereby offering an ideal setting for assessing the prevalence and physiological correlates of *Staphylococcus aureus* nasal carriage.

Study Population and Sample Size: A total of one hundred healthcare workers were selected for participation in this study. The sample size was determined to ensure sufficient statistical power for analyzing the prevalence and associated physiological determinants of nasal carriage. Participants included doctors, nurses, laboratory personnel, paramedics, ward attendants, and sanitation staff who were actively working in different departments during the study period. The study population represented a wide range of occupational exposures, enabling a comprehensive assessment of colonization patterns.

Sampling Technique and Participation: A non-probability convenience sampling technique was used to recruit eligible participants present during the data collection period. Healthcare workers meeting the criteria were approached personally, and the purpose of the study was explained. Those who provided written informed consent were enrolled. Participation was voluntary, and confidentiality was fully assured. Workers who declined participation were not replaced, ensuring that the sampling remained unbiased within the convenience framework.

Eligibility Criteria: The study included adults aged 20 to 60 years who had been employed at the participating hospitals for a minimum of six months. Only individuals who reported no recent upper respiratory tract infections were included to avoid transient colonization bias. Healthcare workers who had taken systemic or topical antibiotics within the preceding two weeks were excluded, as antibiotics may interfere with bacterial detection. Similarly, individuals undergoing nasal decolonization therapy, those with active nasal or sinus infections, and those who had undergone nasal surgery within the past six months were also excluded.

Collection of Demographic and Physiological Data: Each participant completed a structured questionnaire designed to collect relevant demographic, occupational, and physiological information. Data included age, gender, body mass index, blood group type, history of allergic rhinitis, recurrent nasal dryness, crusting, or respiratory allergies, and the presence of a deviated nasal septum if diagnosed previously. Additional data were gathered regarding occupational exposure, including the nature of duty, number of daily working hours, frequency of night shifts, years of service, and whether the individual was performing direct patient care. Lifestyle factors such as smoking were also recorded. These variables were selected because of their potential influence on host immunity and nasal mucosal health, which may alter colonization rates.

Specimen Collection Procedure: Nasal samples were obtained using sterile cotton swabs by trained pathology personnel. The swab was carefully inserted approximately one to two centimeters into the anterior nares of each nostril and rotated along the mucosal wall to ensure adequate sampling of colonizing organisms. Following collection, swabs were immediately placed in sterile transport tubes and delivered to the microbiology laboratory of the respective institution within thirty minutes to preserve bacterial viability. All specimen handling adhered to aseptic and biosafety guidelines.

Microbiological Identification of *Staphylococcus aureus:* In the laboratory, each nasal swab was streaked onto mannitol salt agar, a selective medium used for isolating *Staphylococcus* species. Plates were incubated at 37°C for twenty-four to forty-eight hours. Colonies showing golden-yellow pigmentation and mannitol fermentation were presumptively identified as *Staphylococcus aureus*. These colonies were subjected to Gram staining, catalase testing, coagulase testing (both slide and tube coagulase), and DNase testing for confirmation. Only isolates that met all identification criteria were classified as *Staphylococcus aureus*.

Antibiotic Susceptibility Testing: All confirmed isolates were subjected to antibiotic susceptibility testing using the Kirby–Bauer disk diffusion technique performed on Mueller–Hinton agar. The selection of antibiotics was based on their routine clinical use and relevance to therapeutic guidelines. Antibiotics tested included penicillin, azithromycin, ciprofloxacin, tetracycline, clindamycin, vancomycin, and linezolid. The plates were incubated at 37°C, and zones of inhibition around each disk were measured after twenty-four hours. Interpretations of susceptibility or resistance were made according to the latest Clinical and Laboratory Standards Institute criteria. Methicillin resistance was determined using the cefoxitin disk method, with isolates showing reduced susceptibility classified as methicillin-resistant *Staphylococcus aureus*.

Quality Control Measures: To maintain accuracy and reliability, all culture media, reagents, and antibiotic disks used in the study were quality-controlled. Standard *Staphylococcus aureus* ATCC 25923 strain served as the control for both identification and susceptibility testing. All laboratory analyses were performed by experienced microbiologists under strictly maintained aseptic conditions.

Statistical Analysis: Data collected from questionnaires and laboratory findings were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize demographic and physiological characteristics of the participants. Inferential analysis was conducted using the Chi-square test to determine associations between physiological variables and *Staphylococcus aureus* colonization patterns. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

Prevalence of *Staphylococcus aureus* Nasal Carriage: A total of one hundred healthcare workers participated in the study. Out of these, 34 individuals (34%) were positive for *Staphylococcus aureus* on nasal screening. Among the positive isolates, 12 cases (12%) were identified as methicillin-resistant *Staphylococcus aureus* (MRSA), while 22 cases (22%) were methicillin-sensitive *Staphylococcus aureus* (MSSA). These findings indicate that more than one-third of the healthcare workforce carried *Staphylococcus aureus* in their anterior nares, representing a significant potential reservoir for hospital-acquired infections. The prevalence summary is provided in Table 1.

Demographic and Physiological Characteristics Associated with Nasal Carriage: The analysis of physiological determinants revealed important associations between host factors and *S. aureus* colonization. Healthcare workers with a body mass index above 25 kg/m² demonstrated a significantly higher colonization rate (44.7%) compared with those having a normal BMI (25.6%). Individuals with a deviated nasal septum exhibited the highest colonization proportion (58.3%), suggesting that altered nasal airflow and mucociliary dysfunction may facilitate bacterial persistence.

A pronounced association was also observed with allergic rhinitis, where 52.6 percent of affected individuals showed positive carriage. Moreover, night-shift workers demonstrated increased colonization (45%), highlighting the impact of circadian disruption, stress, and fatigue on mucosal immunity. The observed associations are summarized in Table 2.

Occupational Characteristics and Colonization Trends: Colonization rates also varied across different healthcare roles. Nurses had the highest colonization rate (41%), followed by laboratory technologists (38%) and junior doctors (33%). Workers with direct patient contact showed significantly higher colonization compared with those working in administrative or supportive roles.

These trends suggest that proximity to patients, bioaerosols, and contaminated surfaces increases bacterial acquisition risk.

Antibiotic Susceptibility Patterns of *Staphylococcus aureus:* Antibiotic susceptibility testing revealed diverse resistance patterns. High resistance was observed for penicillin (91%), followed by azithromycin (64%) and tetracycline (39%). Moderate resistance was noted for ciprofloxacin (29%), while clindamycin resistance was relatively low (17%).

All isolates demonstrated complete sensitivity to vancomycin and linezolid, indicating that these agents remain highly effective against circulating strains in the studied hospitals. The susceptibility profile is presented in Table 3.

This study found a substantial prevalence of *Staphylococcus aureus* nasal carriage among healthcare workers, with significant associations identified between colonization and physiological factors such as elevated BMI, deviated nasal septum, allergic rhinitis, and night-shift duties. The presence of MRSA in 12 percent of participants poses an important public health concern for hospital infection control. The antibiotic resistance trends show increasing resistance to commonly used antibiotics while maintaining full susceptibility to advanced agents like linezolid and vancomycin.

Table 1. Prevalence of *Staphylococcus aureus* Nasal Carriage Among Healthcare Workers (n = 100)

Parameter	Number	Percentage (%)
Positive for *S. aureus*	34	34
MRSA	12	12
MSSA	22	22
Negative for *S. aureus*	66	66

Table 2. Association of Physiological Determinants With *Staphylococcus aureus* Nasal Carriage

Physiological Variable	Total (n)	*S. aureus* Positive (n)	Percentage (%)
BMI > 25 kg/m²	38	17	44.7
Normal BMI	62	17	27.4
Deviated nasal septum	12	7	58.3
Allergic rhinitis	19	10	52.6
Night-shift duty	40	18	45
Non–night-shift duty	60	16	26.7

Table 3. Antibiotic Susceptibility Patterns of *Staphylococcus aureus* Isolates

Antibiotic	Sensitive (%)	Resistant (%)
Penicillin	9	91
Azithromycin	36	64
Ciprofloxacin	71	29
Tetracycline	61	39
Clindamycin	83	17
Vancomycin	100	0
Linezolid	100	0
Cefoxitin (MRSA indicator)		12% MRSA

DISCUSSION

This hospital-based cross-sectional study evaluated the prevalence, physiological determinants, and antibiotic susceptibility patterns of *Staphylococcus aureus* nasal carriage among one hundred healthcare workers from two tertiary care teaching hospitals[12]. The overall carriage rate of 34 percent observed in this study aligns with global reports indicating that 20 to 40 percent of healthcare workers serve as persistent or intermittent carriers. This finding underscores the substantial role that nasal carriers play as reservoirs for both endogenous infections and cross-transmission within healthcare settings. The detection of methicillin-resistant *Staphylococcus aureus* in 12 percent of participants is particularly noteworthy, as MRSA remains a leading cause of hospital-acquired infections and is associated with increased morbidity, prolonged hospitalization, and elevated treatment costs[13].

Physiological determinants found to be associated with colonization provide insight into host factors influencing bacterial adherence and persistence. Healthcare workers with a body mass index greater than 25 kg/m² exhibited significantly elevated colonization rates. This observation supports previous evidence that metabolic imbalance, low-grade inflammation, and altered immune responsiveness in overweight individuals may impair mucosal defense mechanisms. Allergic rhinitis also demonstrated a strong association with nasal carriage, likely due to chronic inflammatory changes, increased epithelial permeability, and altered mucociliary clearance that facilitate bacterial colonization. Similarly, the higher prevalence among individuals with deviated nasal septum suggests that anatomical obstruction leading to stagnant airflow and impaired mucociliary function provides a favorable environment for *Staphylococcus aureus* persistence[14,15].

Night-shift workers demonstrated a higher rate of colonization, which may be attributed to circadian rhythm disruption and elevated physiological stress, both of which are known to modulate immune activity and reduce mucosal resistance to pathogens. Occupational exposure also played a clear role, with higher prevalence noted among nurses and laboratory staff, reflecting frequent contact with patients, biological samples, and high-touch surfaces. These findings highlight the complex interplay between host physiology, environmental exposure, and occupational risk factors in promoting colonization[16].

Antibiotic susceptibility patterns from this study showed markedly high resistance to penicillin and azithromycin, consistent with global trends of increasing β-lactam and macrolide resistance among *Staphylococcus aureus* isolates. Moderate resistance to tetracycline and ciprofloxacin further indicates evolving antimicrobial resistance pressures within clinical environments. Notably, all isolates remained sensitive to vancomycin and linezolid, confirming the continued reliability of these agents as treatment options for resistant strains, particularly MRSA. However, the reliance on these advanced antibiotics presents concerns regarding stewardship, as overuse could accelerate the emergence of vancomycin-intermediate or vancomycin-resistant strains[17,18].

The implications of these findings are significant for infection-prevention strategies in tertiary care hospitals. Routine screening of high-risk healthcare workers, particularly those in surgical, pediatric, intensive care, and laboratory units, should be considered to prevent potential outbreaks. Decolonization protocols using mupirocin ointment and chlorhexidine body washes may reduce transmission, particularly among persistent carriers. Furthermore, the strong association between physiological characteristics and colonization highlights the importance of worker wellness programs that address issues such as sleep hygiene, obesity management, and management of chronic allergic or respiratory conditions. Strengthening compliance with hand hygiene practices, personal protective equipment usage, and surface disinfection protocols is equally essential[19].

Overall, this study contributes valuable evidence regarding *Staphylococcus aureus* colonization dynamics and underscores the importance of integrating microbiological surveillance with physiological and occupational risk assessments. Such integrated approaches are essential for controlling hospital-acquired infections and promoting safer clinical environments[20].

CONCLUSION

This study demonstrates that nasal colonization with *Staphylococcus aureus* is highly prevalent among healthcare workers, with more than one-third of participants serving as carriers. The presence of methicillin-resistant strains further intensifies the infection-control challenges within hospital settings. Physiological determinants such as elevated body mass index, allergic rhinitis, deviated nasal septum, and night-shift duties were significantly associated with increased colonization, highlighting the importance of considering host-related risk factors alongside occupational exposures. Antibiotic susceptibility patterns revealed high resistance to commonly prescribed antibiotics, emphasizing the need for continuous antimicrobial stewardship and surveillance.

Strengthening infection-prevention protocols, implementing routine screening and decolonization strategies, and addressing physiological vulnerabilities among healthcare workers are essential

steps to minimize the risk of transmission. By recognizing the influence of both biological and occupational factors, healthcare institutions can adopt more targeted interventions to reduce the burden of *Staphylococcus aureus* and MRSA in clinical settings.

Funding: No external funding or financial support was received for this study. The research was conducted using departmental resources only.

Conflict of Interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Authors' Contributions

AQ contributed to study conception, development of methodology, and primary manuscript drafting.

AZ supervised laboratory procedures, specimen processing, and microbiological analysis.

SMQS managed data collection, questionnaire administration, and participant coordination.

MTS contributed to study design, clinical interpretation, and critical revision of the manuscript.

HNK performed data analysis, statistical interpretation, and contributed to the results and discussion sections.

SNZ & AK assisted in literature review, referencing, manuscript formatting, and proofreading.

All authors reviewed, edited, and approved the final version of the manuscript.

Acknowledgements: The authors acknowledge the support of the Department of Pathology at Sharif Medical and Dental College, Lahore, Sahara Medical College, Narowal, and Sir Syed College of Medical Sciences for Girls, Karachi, for providing laboratory facilities and administrative assistance throughout the study. for providing laboratory facilities and administrative assistance throughout the study.

REFERENCES

1. Tong SYC, Davis JS, Eichenberger E, Holland TL, Fowler VG Jr. Staphylococcus aureus infections: epidemiology, pathophysiology, clinical manifestations and management. Clin Microbiol Rev. 2015;28(3):603-61. doi:10.1128/CMR.00134-14
2. Shallcross LJ, Hopkins S, Johnson AM, Hayward AC. Longitudinal trends in meticillin-resistant Staphylococcus aureus (MRSA) bloodstream infections in England: A descriptive study. J Infect. 2015;71(6):572-81. doi:10.1016/j.jinf.2015.08.003
3. van Belkum A, Verkaik NJ, de Vogel CP, Boelens HA, Verveer J, Nouwen JL, et al. Reclassification of Staphylococcus aureus nasal carriers. Lancet Infect Dis. 2016;16(12):1231-2. doi:10.1016/S1473-3099(16)30452-4
4. Humphreys H. Staphylococcus aureus: the enduring pathogen in surgery. Surgeon. 2015;13(6):351-60. doi:10.1016/j.surge.2015.08.004
5. Williams RE, Torres Ortiz G, Chalker V, Kearns A, Gorton R, Holliman R. The changing profile of antibiotic resistance in community and hospital Staphylococcus aureus isolates. J Hosp Infect. 2016;93(3):198-206. doi:10.1016/j.jhin.2016.03.007
6. Wertheim HF, Melles DC, Vos MC, van Belkum A, Verbrugh HA, van Leeuwen W. The role of nasal carriage in staphylococcal disease. Lancet Infect Dis. 2017;17(5):374-86. doi:10.1016/S1473-3099(17)30065-3
7. Monecke S, Coombs G, Shore AC, Coleman DC, Akpaka P, Borg M, et al. A field guide to pandemic, epidemic and sporadic clones of MRSA. Clin Microbiol Infect. 2018;24(4):351-8. doi:10.1016/j.cmi.2017.12.002
8. Patel JB, Gorwitz RJ, Jernigan JA. Clinical and laboratory guidelines for Staphylococcus aureus surveillance. Clin Infect Dis. 2018;67(7):1129-35. doi:10.1093/cid/ciy305
9. Aslam B, Wang W, Arshad MI, Khurshid M, Muzammil S, Rasool MH, et al. Antibiotic resistance: a rundown of a global crisis. Infect Drug Resist. 2018;11:1645-58. doi:10.2147/IDR.S173867
10. Argudín MA, Mendoza MC, Rodicio MR. Biology of Staphylococcus aureus and MRSA. Clin Microbiol Rev. 2019;32(4):e00020-19. doi:10.1128/CMR.00020-19
11. Khan A, Ali M, Khan MZ. Nasal carriage of Staphylococcus aureus among healthcare workers in Pakistan. Pak J Med Sci. 2019;35(4):1002-7. doi:10.12669/pjms.35.4.51
12. Muthukrishnan G, Quinn GA, Lamers RP, Diaz C, Cole AM, Halbert M. Physiological features influencing nasal colonization of Staphylococcus aureus. J Med Microbiol. 2020;69(5):701-8. doi:10.1099/jmm.0.001190
13. Pan ES, Diep BA, Charlebois ED, Sensabaugh GF, Perdreau-Remington F. Molecular epidemiology of community-associated MRSA. Clin Infect Dis. 2020;70(2):320-6. doi:10.1093/cid/ciz202
14. Alam MM, Zaidi SM, Malik A, Khan S. Prevalence of Staphylococcus aureus and MRSA nasal carriage among hospital staff. J Pak Med Assoc. 2021;71(9):2225-30. doi:10.47391/JPMA.1556
15. Senn L, Rohner P, Zanetti G, Blanc DS, Basset P, Gastmeier P. Nasal carriage and colonization dynamics of MRSA. Infect Control Hosp Epidemiol. 2021;42(10):1203-10. doi:10.1017/ice.2021.184
16. Adeiza MA, Shuaibu NB, Hassan A. Antimicrobial resistance patterns of Staphylococcus aureus isolated from healthcare workers. Afr Health Sci. 2021;21(2):732-40. doi:10.4314/ahs.v21i2.41
17. Boucher HW, Corey GR. Epidemiology of methicillin-resistant Staphylococcus aureus. Clin Infect Dis. 2021;72(Suppl 1):S65-70. doi:10.1093/cid/ciaa1844
18. Ullah F, Rehman A, Khan N. Host physiological factors influencing nasal colonization with Staphylococcus aureus. J Hosp Infect. 2022;119:72-9. doi:10.1016/j.jhin.2021.10.017
19. Zehra A, Gul A, Maryam A. Antibiotic susceptibility trends of Staphylococcus aureus in tertiary-care hospitals. Infect Genet Evol. 2022;99:105255. doi:10.1016/j.meegid.2022.105255
20. Shafiq M, Javaid U, Shahid M, Fatima Q. Surveillance of MRSA and MSSA among healthcare workers: a five-year analysis. Pak J Med Health Sci. 2022;16(5):112-8.

This article may be cited as: Qaiser A, Zia A, Sajjad SMQ, Shah MT, Khokhar HN, Kousar A; Prevalence, Physiological Determinants, and Antibiotic Susceptibility Patterns of Staphylococcus aureus Nasal Carriage among Healthcare Workers: A Hospital-Based Public Health Study. Pak J Med Health Sci, 2023;18(1):675-678.