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Original Research Article

Assessment Knowledge and Practice Among Pharmacy, Nursing, and Medical Students Regarding Hand Hygiene in Saudi Arabia

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Abstract

Background: Hand hygiene is the key to prevent spread of infections in any health care setting. It is vital to understand and assess health care students knowledge and understanding towards hand hygiene so that effective infection control can be ensured.
Objectives: To examine the handwashing knowledge and practice of final year pharmacy, nursing, and medical students from Saudi Arabia.
Materials and Methods: A cross-sectional study was conducted using an online study questionnaire. Students from various health sciences disciplines were approached to participate in this study. The Shapiro–Wilk test was employed to assess the normality of distribution, and the reliability of the knowledge and perception survey was evaluated; Cronbach's alpha values were .88 and .75, respectively. The Shapiro–Wilk test was employed to assess the normality of the distribution. One-way Kruskal–Wallis and Mann–Whitney *U* tests were used to assess the difference in the knowledge among different groups. A *p* value less than .05 was considered statistically significant.
Results: Results have shown that 65.9% of participants were male and 52.3% were in the 21–25 age group. 41.05% were pharmacy students, followed by the other disciplines. It was revealed that 92.9% were aware of the significance of hand hygiene and had the most understanding of the concept, methods, and time required for the procedure of hand hygiene. However, 21.3% of respondents also held misconceptions about the effectiveness of alcohol-based hand sanitizers. According to personal practices, 89.1% cleaned their hands after coming into contact with body fluids, and 83.2% did so both before and after interaction with patients. It was observed that female respondents had significantly greater knowledge (10.11 ± 0.19, $p = .001$) about hand hygiene practices and applied practices in day-to-day care (5.11 ± 0.25, $p = .037$).
Conclusion: Overall, the understanding of the concept of hand hygiene among the respondents was good. Being a female and a medical student were found to be the two main factors associated with better knowledge and understanding of hand hygiene practices.

Keywords

Hand hygiene, knowledge, attitude, perception

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Introduction

Handwashing is a top priority for healthcare providers to prevent infection control among healthcare professionals.[1–3] It was shown that handwashing before and after healthcare procedures can greatly reduce healthcare-associated infection (HCAI) transmission.[1,4,5] Healthcare personnel are not only transmitting infections through contact with clinical apparatus, patients, and other items/equipment that are used in direct patient care, but they may also further transmit it via contact with non-clinical items/equipment, that is, computers, keyboards, phones, and electronic devices, which are increasingly used in all healthcare sectors.[6,7] Hands serve as the primary means for the transfer of pathogens from an infected individual to a healthy one.

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According to the World Health Organization, hand hygiene is essential for preventing numerous infectious diseases.[8] Research indicates that adherence to proper hygiene practices can prevent millions of deaths each year.[9] The application of anti-septics for hand hygiene following patient contact minimizes the likelihood of disease transmission.[10] Numerous guidelines have been established regarding hand hygiene, advocating for the use of alcohol-based hand sanitizers (with a minimum concentration of 60%) or mechanical handwashing to effectively eliminate pathogens and prevent their transmission.[11]

Previous studies conducted during the outbreaks of severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) have established the effectiveness of implementing proper hand hygiene practices in conjunction with additional measures to mitigate the emergence of these viruses.[12] A meta-analysis indicates that adherence to hand hygiene guidelines can lead to a reduction of up to 21% in the rate of upper respiratory tract infections.[13] Evidence indicates that, despite awareness of hand hygiene practices, compliance with these practices remains difficult. Assessing the situation in the Saudi healthcare setting, hand hygiene among health sciences students remained a big concern, and some studies have reported considerable knowledge differences.[14–16] It is observed in the Saudi healthcare setting that health sciences students attending internships in the hospital setting may pose a major threat to patients and personal safety if their understanding of hand hygiene is poor,[14–16] and some report moderate knowledge regarding hand hygiene practices among nursing students. Despite this crucial practice, health sciences students were found to have a variable level of compliance with handwashing, which may be due to insufficient experience with these practices, resource constraints, time required for implementation, and accessibility of disinfectants.[5,17,18]

Therefore, hand cleaning is crucial; handwashing can prevent the spread of the most serious infectious diseases. To prevent the infection from spreading, the healthcare personnel and students must be aware of the hand hygiene practices and must show compliance as per guidelines. To reduce HCAIs, Saudi students' handwashing knowledge and practice must be assessed. This study examined the handwashing knowledge and practice of final year pharmacy, nursing, and medical students from Saudi Arabia.

Materials and Methods

A cross-sectional study design was adapted to attain the aims of this study. The duration of this study lasted from May 1, 2024, to June 30, 2024. To collect data, an online method was utilized, and Google Forms were used to disseminate them to the group of students studying medicine, nursing, and pharmacy across the kingdom. These forms were circulated via various social media sites to get the desired responses.

Sample Size

An online sample size calculator, Raosoft®, was used to estimate the minimum sample size for this study. The estimated sample size for this study was found to be $n = 377$ at the confidence interval of 95% with a margin of error of 5%.

Development of Study Tools

Various international studies that have explored healthcare professionals' knowledge, attitude, and perception toward hand hygiene and practices were referred to as the development of a study tool. To determine the face validity of the questionnaire and the degree of difficulty it posed, a pilot test was conducted with 30 students before it was sent to the public. Those findings from the pilot research were not included in the primary study. The reliability of the knowledge and perception survey was evaluated, and the results showed that Cronbach's alpha values were .88 and .75, respectively.

Study Questionnaires and Procedure

The survey included three distinct sets. The initial set focused on demographic variables such as gender, educational level, and marital status, utilizing multiple-choice questions for data collection. The second set comprised questions related to handwashing knowledge, featuring a total of 12 items assessed through three response options: "yes," "no," or "I do not know." The final series of inquiries pertained to the implementation of hand hygiene and utilized a three-point Likert-type scale (always, sometimes, and never). The anonymous questionnaires submitted by the respondents were thoroughly checked for accuracy and entered into the Statistical Package for Social Science (SPSS) database. Additionally, the completed questionnaires were securely stored, ensuring the privacy of the data was maintained throughout the study. The knowledge scores were determined by giving a score of "1" for correct answers and a score of "0" for incorrect answers, and "I do not know." In a similar manner, the practice score was determined. The overall mean knowledge and practice scores were calculated by summing the total knowledge items and the total practice items, respectively.

Data Analysis

The collected data were assessed for questionnaire completeness; participants missing more than two items were classified as having incomplete responses and were excluded from the study. Data analysis was conducted using IBM SPSS Statistics 22 (IBM Inc., Chicago, IL, USA) software. Data were summarized using descriptive statistics, frequencies, and percentages. Mean scores for knowledge and practice were computed based on the respective questionnaires. The

Shapiro–Wilk test was employed to assess the normality of distribution, revealing that the data did not conform to a normal distribution. Non-parametric tests, including the Mann–Whitney *U* test and the Kruskal–Wallis test, were employed to identify differences in knowledge and practice scores relative to the demographic characteristics of the participants. A p value below .05 was deemed statistically significant.

Results

A total of n = 1,071 online questionnaires were received, of whom n = 1,033 (96.5%) were complete and considered for further analysis. Upon analysis, it was revealed that 65.9% of respondents who responded to the study were men and 34.1% were women. The majority of 540 (52.3%) were from the age group of 21–25 years, and 41.05% of the respondents were pharmacy students. Details are shown in Table 1.

Table 1. Demographics of the Respondents.

Characteristics of Respondents	Frequency (*N*)	%
Gender		
Male	680	65.9
Female	353	34.1
Age (in Years)		
19–20	420	40.7
21–25	540	52.3
26 and over	73	7.0
Profession		
Pharmacy nursing	423	41.0
Medical	331	32.0
Others	279	27.0

Knowledge and Practices of Hand Hygiene Among Students

The survey results demonstrate significant awareness of the importance of hand hygiene among healthcare workers. A substantial majority (92.9%) acknowledged that HCAIs predominantly transmit through close contact, and about 85.2% recognized the importance of regular handwashing for infection prevention in healthcare environments. Among the few, 12.6% had some misconceptions, believing handwashing was unnecessary for those exercising caution. This misconception underscores the necessity for enhanced education regarding the significance of hand hygiene as a universal preventive strategy. Furthermore, 6.8% of respondents erroneously believed that handwashing is unnecessary when gloves are worn properly. This highlights a deficiency in the comprehension of glove usage protocols and the risk of glove contamination.

A majority (92.9%) recognized the importance of handwashing upon entering a healthcare facility. Additionally, 92% acknowledged that effective hand hygiene entails a comprehensive procedure that includes wetting, lathering, friction, rinsing, and drying. The survey indicated that 89% of respondents recognized the advised handwashing duration of 10–15 s. The data indicate a varied comprehension of hand hygiene techniques. While 92.9% acknowledged the necessity of hand hygiene before and after glove removal, only 92.9%

Table 2. Students' Knowledge and Understanding of Hygiene Practices Should Be Adapted for the Prevention of Infection.

Statements	Yes (*n*)	No (*n*)	Do Not Know (*n*)
1. Transmission of healthcare-associated infections typically occurs through close contact.	970 (93.9%)	30 (2.9%)	33 (3.2%)
2. Infections in healthcare settings can be prevented through regular handwashing.	960 (92.9%)	50 (4.8%)	23 (2.22%)
3. For individuals who exercise caution, washing their hands is unnecessary.	880 (85.2%)	140 (13.6%)	–
4. When using gloves correctly, washing hands is unnecessary.	900 (87.1%)	130 (12.6%)	–
5. Upon entering a healthcare facility, medical personnel should always wash their hands thoroughly.	950 (92.0%)	70 (6.8%)	13 (1.25%)
6. Proper hand hygiene is essential, regardless of whether gloves are worn or not.	960 (92.9%)	70 (6.8%)	3 (0.29%)
7. Thoroughly washing one's hands involves wetting them, lathering them with soap, exerting friction, rinsing them, and finally drying them.	950 (92.0%)	80 (7.8%)	3 (0.29%)
8. It is recommended to wash hands for a minimum of 10–15 seconds.	760 (73.5%)	260 (25.2%)	13 (1.25%)
9. The bacterial load on hands can be reduced by using disinfectants while washing them.	920 (89.0%)	110 (10.7%)	3 (0.295%)
10. Medical personnel should wash their hands thoroughly or apply an anti-septic hand rub before and after removing gloves.	960 (92.9%)	70 (6.8%)	–
11. When compared to water, alcohol's capacity to kill germs is far higher.	810 (78.4%)	220 (21.3%)	–
12. The best defense against the transmission of disease is washing hands frequently.	920 (89.0%)	110 (10.7%)	3 (0.29%)

understood that disinfectants can decrease the bacterial load on hands during washing. This suggests a possible deficiency in understanding optimal hand hygiene practices and in applying hand sanitizers.

In addition, 89% acknowledged that regular handwashing is the most effective measure to prevent disease transmission. Nonetheless, 21.3% of respondents did not recognize that alcohol's ability to kill germs exceeds that of water. This indicates the necessity to enhance the efficacy of alcohol-based hand rubs as an essential element of hand hygiene protocols. Details are shown in Table 2.

Personal practices of the respondents were explored in this section; 860 (83.2%) of respondents reported that they washed their hands before and after handling patients. In addition, 920 (89.1%) of respondents reported washing their hands after touching body fluids, and 79.4% ensured strict compliance with these practices by always remembering to sanitize their hands. About 83.2% were using soap to wash hands, while 59.1% were using alcohol-based scrubs on a regular basis. Details are shown in Table 3.

Finally, comparison of knowledge scores and practices was performed using age, gender, and profession as the grouping variables. It was observed that female respondents were significantly better in their knowledge (10.11 ± 0.19, $p = .001$) about hand hygiene practice and applied practices in day-to-day care (5.11 ± 0.25, $p = .037$). Although no significant differences were observed in these two domains by age, respondents aged >26 years demonstrated a better understanding of hand hygiene knowledge and applied practices in day-to-day care. Finally, in the areas of study or profession, medical students were found to have a better understanding of hand hygiene and its applied practices in day-to-day care, followed by pharmacy and nursing students. Details are shown in Table 4.

Discussion

The first practical step in preventing infection in both hospital and non-hospital settings is practicing good hand hygiene. Before entering healthcare organizations as future healthcare professionals, healthcare students must receive comprehensive training in basic infection prevention strategies. They should be prepared for the most basic forms of infection prevention during their professional education at the university level. This study examines the level of knowledge and

Table 3. Personal Practices of the Respondents While Handling and Attending Patients.

Statements	Always (*n*) %	Sometimes (*n*) %	Never (*n*) %
1. Always use hand sanitizer/wash hands before and after handling patients.	860 (83.2%)	170 (16.5%)	3 (0.3%)
2. After touching bodily fluids, wash your hands thoroughly.	920 (89.1%)	110 (10.7%)	3 (0.3%)
3. Always remember to wash your hands before aseptic dispensing.	820 (79.4%)	210 (20.3%)	3 (0.3%)
4. While washing your hands, use soap.	860 (83.2%)	170 (16.5%)	3 (0.3%)
5. For proper hand hygiene, use an alcohol-based hand scrub or liquid.	610 (59.1%)	410 (39.7%)	13 (1.3%)
6. After washing hands, always dry them.	760 (73.5%)	260 (25.2%)	13 (1.3%)

Table 4. Difference in Knowledge and Practices Scores.

Characteristics	Knowledge Scores Mean ± SD	*p* Value	Practice Scores Mean ± SD	*p* Value
Gender				
Male	9.12 ± 1.43	.001*	4.79 ± 0.23	.037*
Female	10.11 ± 0.19		5.11 ± 0.25	
Age Group				
19–20 years	9.81 ± 0.22	.818	4.85 ± 0.21	.195
21–25 years	9.71 ± 0.20		4.75 ± 0.16	
>26 years	9.99 ± 0.27		5.23 ± 0.33	
Profession				
Pharmacy	9.80 ± 0.26	.577	4.80 ± 0.20	.047*
Nursing	9.78 ± 0.19		4.89 ± 0.16	
Medical	10.05 ± 0.08		5.31 ± 0.15	

Note: *Significant, Mann–Whitney *U* test and Kruskal–Wallis test were applied.

practices of hand hygiene among final year medical, nursing, and pharmacy students from different universities of Saudi Arabia. Although there were some misconceptions and gaps, overall, a good level of knowledge about hand hygiene was observed among the studied population.

Knowledge

According to the findings of our study, majority of the students (92.9%) correctly identified the importance of hand hygiene in preventing HCAIs. This finding is consistent with research done by Syed and Al-Rawi, which found that 94.2% of nursing students identified direct or indirect contact as the primary mode of HCAI transmission,[19] and according to Humran and Khalid, 84.22% of nursing students had good knowledge about hand hygiene.[20] Similar results were also reported by Ayyappan and Ismail, who found that 98.63% of nursing students reported having adequate knowledge regarding hand hygiene.[21] This implies a high level of baseline knowledge in all Saudi healthcare education initiatives. In a similar study performed by Yaseen et al., a significantly better level of knowledge about hand hygiene was observed in the urban population of Pakistan.[22]

Nonetheless, a significant percentage in every study continues to hold false beliefs. For example, 12.6% of students in our survey thought handwashing was unnecessary when wearing gloves, consistent with 12.2% in Syed and Al-Rawi's study.[19] These frequent misconceptions highlight the ongoing disconnect between theoretical understanding and its application, pointing to the need for additional hands-on, scenario-based instruction.

Gender and Professional Education—Knowledge

In line with findings by Syed and Al-Rawi, where female nursing students showed significantly better hygiene practices (mean practice score 5.00 vs. 4.62, $p = .037$),[19] one important finding from our study was that female students outperformed males in both knowledge and practice. In contrast to our findings, no difference in knowledge about hand hygiene was observed between males and females in a similar study performed in Saudi Arabia.[20] When creating focused instructional initiatives, this gender disparity should be considered, since it can represent behavioral and perceptual variations seen in various healthcare settings.

As far as the impact of professional education on knowledge and practices is concerned, the findings of our study revealed that medical students had better knowledge scores (10.05 ± 0.08) as compared to the pharmacy (9.80 ± 0.26) and nursing (9.78 ± 0.19) students. Similarly, hand hygiene practice scores were significantly better among medical students (5.31 ± 0.15) in comparison to the nursing (4.89 ± 0.16) and pharmacy (4.80 ± 0.20) students. However, according to Syed and Al-Rawi, nursing students adhered more to the hand hygiene guidelines as compared to their counterparts.[19]

Increased clinical exposure and the focus on infection management in the medical curriculum may be the cause of these findings. Yaseen et al. highlighted that behavioral and environmental hurdles may make it difficult for even educated people to apply practices, suggesting that knowledge by itself may not be enough to motivate compliance.[22]

Practice and Adherence

Although the knowledge scores of our study participants were high, only 59.1% routinely utilized alcohol-based hand massages, even though 83.2% of them reported consistently washing their hands before and after patient interaction, and 89.1% after coming into contact with bodily fluids. This is consistent with research by Syed and Al-Rawi, which showed that 59.9% of nursing students used hand rubs containing alcohol, suggesting a regional trend of underuse of potent disinfectants.[19] Similar results were also reported by Ayyappan and Ismail, who found that 48% of health science students routinely washed their hands using alcohol-based hand rub.[21] Of those, 26% of the students were only aware that applying an alcohol-based hand massage takes 20 s to eradicate hand germs.[21] One of the main causes of inadequate hand hygiene habits may be a lack of awareness regarding the anti-microbial properties of alcohol-based hand washes. According to research by Takpere et al., only 38.1% of Indian medical students were aware that alcohol-based hand rubs can kill bacteria on the hands.[23]

Syed et al. found that despite acknowledging the importance of disinfecting their stethoscope by the majority of the physicians (above 80%), only 47% adhered to the stethoscope disinfection guidelines.[24] Similar gaps were seen by Yaseen et al., who attributed them to expense, forgetfulness, and a lack of knowledge of effectiveness barriers that are reflected in both our findings and the larger body of research on behavioral health treatments.[22]

According to Yaseen et al., forgetfulness, doubts about the effectiveness of products, and product availability were major obstacles to practicing good hand hygiene.[22] This supports our results that implementation lags behind even with sufficient information, particularly for actions like applying hand sanitizers or drying hands.

There is a persistent gap in putting information into practice, even if knowledge levels are typically good across studies. This shift is influenced by variables including the nature of the profession, education level, gender, availability of disinfectants, and lack of perceived urgency.

Implementation of hand hygiene training programs,[25] establishing role models and mentoring programs, has shown improvements in the knowledge and practices of the medical, nursing, and pharmacy students.[26,27] By emphasizing the value and proper methods of hand hygiene, educational institutions may close these gaps through simulation-based learning, interactive workshops, and integrated curriculum.

Strengths and Limitations

This is perhaps among the very few studies that investigate this issue in the Saudi setting. Findings of this study will assist the policymakers in conducting suitable reforms to cover the deficit in the learning and training of the students. This study also has a few limitations. Saudi Arabia is a very diverse region, and being an online study, it is possible that the results of this study might vary from those of others. The sample was mostly online; therefore, it was not possible for those who had limited access to the internet or online platforms where this survey was posted.

Conclusion

Medical students have a better understanding of health hygiene and practices than the other groups. In terms of gender, females, and in terms of age, those with age >26 years were found to have a better understanding of health hygiene and practices.

Abbreviations

HCAI: Healthcare-associated infection; **IBM:** International Business Machines; **IL:** Illinois; **MERS-CoV:** Middle East respiratory syndrome coronavirus; **SARS-CoV:** Severe acute respiratory syndrome coronavirus; **SD:** Standard deviation; **SPSS:** Statistical Package for Social Science; **USA:** United States; **WHO:** World Health Organization.

Declaration of Conflicting Interests

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References

1. Nasirudeen AM, Koh JW, Lau AL, et al. Hand hygiene knowledge and practices of nursing students in Singapore. *Am J Infect Control* 2012; 40(8): e241–e243. doi:10.1016/j.ajic.2012.02.026. PMID 22884496.
2. Alothman A, Al Thaqafi A, Al Ansary A, et al. Prevalence of infections and antimicrobial use in the acute-care hospital setting in the Middle East: results from the first point-prevalence survey in the region. *Int J Infect Dis* 2020; 101: 249–258. doi:10.1016/j.ijid.2020.09.1481. PMID 33031939.
3. Sahay S, Panja S, Ray S, et al. Diurnal variation in hand hygiene compliance in a tertiary level multidisciplinary intensive care unit. *Am J Infect Control* 2010; 38(7): 535–539. doi:10.1016/j.ajic.2010.03.013. PMID 20579772.
4. Ragusa R, Marranzano M, Lombardo A, et al. Has the COVID 19 virus changed adherence to hand washing among healthcare workers? *Behav Sci (Basel)* 2021; 11(4): 53. doi:10.3390/bs11040053. PMID 33920791.
5. Bargellini A, Ferranti G, Santangelo M, et al. Students' hand contamination before and after a training shift: relationship with self-reported hand hygiene adherence. *Epidemiol Biostat Public Health* 2022; 11(4). doi:10.2427/9971
6. Collins J. Letter from the editor: fighting germs in the workplace. *Semin Roentgenol* 2007; 42(1): 1–2. doi:10.1053/j.ro.2006.08.005. PMID 17174167.
7. Messina G, Quercioli C, Burgassi S, et al. How many bacteria live on the keyboard of your computer? *Am J Infect Control* 2011; 39(7): 616–618. doi:10.1016/j.ajic.2010.12.023. PMID 21782282.
8. World Health Organization. Infection prevention and control during health care when novel coronavirus (nCoV) infection is suspected: interim guidance. Geneva: World Health Organization; 2020 Jan 25.
9. Larson EL, Quiros D, and Lin SX. Dissemination of the CDC's Hand Hygiene Guideline and impact on infection rates. *Am J Infect Control* 2007; 35(10): 666–675. doi:10.1016/j.ajic.2006.10.006. PMID 18063132.
10. Woodford N and Livermore DM. Can we beat MRSA now we know its genome sequence? *Lancet Infect Dis* 2001; 1(1): 9–10. doi:10.1016/S1473-3099(01)00015-9. PMID 11871420.
11. Glowicz JB, Landon E, Sickbert-Bennett EE, et al. SHEA/IDSA/APIC Practice Recommendation: strategies to prevent healthcare-associated infections through hand hygiene: 2022 update. *Infect Control Hosp Epidemiol* 2023; 44(3): 355–376. doi:10.1017/ice.2022.304. PMID 36751708.
12. Otter JA, Donskey C, Yezli S, et al. Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: the possible role of dry surface contamination. *J Hosp Infect* 2016; 92(3): 235–250. doi:10.1016/j.jhin.2015.08.027. PMID 26597631.
13. Aiello AE, Coulborn RM, Perez V, et al. Effect of hand hygiene on infectious disease risk in the community setting: a meta-analysis. *Am J Public Health* 2008; 98(8): 1372–1381. doi:10.2105/AJPH.2007.124610. PMID 18556606.
14. Wade S. Partnership in care: a critical review. *Nurs Stand* 1995; 9(48): 29–32.
15. Cruz JP and Bashtawi MA. Predictors of hand hygiene practice among Saudi nursing students: a cross-sectional self-reported study. *J Infect Public Health* 2016; 9(4): 485–493. doi:10.1016/j.jiph.2015.11.010. PMID 26707706.
16. Cruz JP, Cruz CP, and Al-Otaibi AS. Gender differences in hand hygiene among Saudi nursing students. *Int J Infect Control* 2015; 11(4). doi:10.3396/ijic.v11i4.029.15
17. Alshamrani MM, El-Saed A, Alsaedi A, et al. Burden of healthcare-associated infections at six tertiary-care hospitals in Saudi Arabia: a point prevalence survey. *Infect Control Hosp Epidemiol* 2019; 40(3): 355–357.

18. Al Saleh S, Al Rammah AA, Syed W, et al. Stethoscope hygiene and barriers among physicians—a cross-sectional study from National Guard Health Affairs in Dammam, Saudi Arabia. *J Patient Saf Infect Control* 2019; 7(2): 53–58.
19. Syed W and A Al-Rawi MB. Assessment of hand-washing knowledge and practice among nursing undergraduates in Saudi Arabia. *Can J Infect Dis Med Microbiol* 2024; 2024(1): 7479845.
20. Humran MB and Alahmary K. Assessment of knowledge, attitude, and practice of hand hygiene among medical and health profession students at King Saud Bin Abdulaziz University for Health Sciences in Saudi Arabia. *Saudi Crit Care J* 2018; 2(4): 66–72.
21. Ayyappan JP and Ismail GM. Assessment of knowledge, practices, and attitude of hand hygiene among university nursing and optometry undergraduate students in their final year of training. *Malays J Public Health Med* 2021; 21(2): 226–233.
22. Yaseen MO, Saif A, Khan TM, et al. A qualitative insight into the perceptions and COVID-19 vaccine hesitancy among Pakistani pharmacists. *Hum Vaccines Immunother* 2022; 18: 2031455. doi:10.1080/21645515.2022.2031455
23. Takpere A, Biradar VS, and Reddy S. Evaluation of oral hygiene awareness and practices among medical students. *Int J Community Med Public Health* 2016; 3(1): 83–85.
24. Syed W, Al Saleh S, Al Rammah AA, et al. Stethoscope hygiene and barriers among physicians—a cross-sectional study from National Guard Health Affairs in Dammam, Saudi Arabia. *J Patient Saf Infect Control* 2019; 7(2): 53. doi:10.4103/jpsic.jpsic_19_19
25. Alhenn AS, Yousef A, Mhawsh M, et al. Hand hygiene championship: a direct observational study. *Infect Control Hosp Epidemiol* 2013; 34(10): 1126–1127.
26. Amin TT, Al Noaim KI, Bu Saad MA, et al. Standard precautions and infection control, medical students' knowledge and behavior at a Saudi University: the need for change. *Glob J Health Sci* 2013; 5(4): 114–125. doi:10.5539/gjhs.v5n4p114. PMID: 23777728; PMCID: PMC4776810.
27. Al Kadi A and Salati SA. Hand hygiene practices among medical students. *Interdiscip Perspect Infect Dis* 2012; 2012(1): 679129.