RESEARCH PAPER

Beliefs, Knowledge, and Practices of Hand Hygiene among Operating Room Personnel

Ahmad Mahmoud Saleh, Ph.D.[1*], Amira Abd El-azeem Mohamed Yossif, Ph.D.[1], Wafaa Mohamed Amer Mahmoud, Ph.D.[1], Wafaa Mohamed Elsayed Ahmed, Ph.D.[2], Sabah Ahmed Ammar Mohamed, Ph.D.[1, 3]

[1*] Nursing College, Prince Sattam bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia.
Email: am.saleh@psau.edu.sa, ORCID: https://orcid.org/0000-0002-3529-4139 (Corresponding Author)
[2] Faculty of Nursing, Al Ryada University for Science and Technology, Egypt.
[3] Faculty of Nursing, Helwan University, Cairo, Egypt.

Received: 20th Feb, 2026 | **Revised:** 4th Mar, 2026 | **Accepted:** 25th Mar, 2026 | **Available Online:** 10th Apr, 2026

ABSTRACT

Introduction: Hand hygiene is a cornerstone of infection prevention, critically vital in operating rooms where patients are highly vulnerable to healthcare-associated infections (HAIs). Despite its importance, compliance remains inconsistent. Improving adherence is a critical component of patient safety and infection prevention efforts.

Purpose: The study assessed operating room staff's hand hygiene beliefs, knowledge, practices, and factors affecting compliance.

Methods: A descriptive cross-sectional study was conducted over a three-month period (June-August 2022) in the operating rooms of a government hospital in AlKharj, Saudi Arabia. A total of 65 operating room staff using a demographic survey, the Hand Hygiene Belief Scale (HHBS), and the Hand Hygiene Practice Inventory (HHPI). Data were analyzed with IBM SPSS Statistics 29. Cronbach's alpha assessed reliability, and multiple linear regression was applied ($p < 0.05$).

Results: Participants included physicians (56.9%), nurses (40.0%), and cleaning staff (3.1%). The mean HHBS score was 98.7 ± 8.9, higher than the HHPI score (83.8 ± 13.0), reflecting stronger beliefs than practices. Multiple linear regression showed that marital status and workplace duration were significant predictors of HHBS scores ($R^2 = 0.122$), while gender, education, and handwashing duration were significant predictors of HHPI scores ($R^2 = 0.232$; all $p < 0.05$ for main predictors). Job type and gender were significant factors in compliance before and after patient contact.

Conclusion: Hand hygiene compliance is influenced by demographic and professional factors. Targeted interventions are essential to improve practice, reduce HAIs, and contribute to public health priorities in infection control.

Keywords: Hand hygiene, infection control, operating room staff, healthcare-associated infections.

How to cite this article: Saleh AM, Yossif AAEM, Mahmoud WMA, Ahmed WME, Mohamed SAA. Beliefs, Knowledge, and Practices of Hand Hygiene among Operating Room Personnel. Int J Drug Deliv Technol. 2026;16(28s):1104-1114. DOI: 10.25258/ijddt.16.28s.125

Source of support: Nil.

Conflict of interest: The authors declare no conflict of interest.

Introduction

Maintaining proper hand hygiene is essential for preventing the spread of healthcare-associated infections (HAIs) (1). In operating rooms, surgeons and all staff who enter under sterile conditions must perform surgical hand antisepsis to reduce the

transmission of microorganisms between patients (2). Before washing, all jewelry—such as watches, rings, and bracelets—must be removed. Hands and forearms should be cleaned thoroughly (including nail beds) with a soft brush using an appropriate antiseptic solution, for about three to five minutes, followed by drying with a sterile towel (3).

Among antiseptic agents, chlorhexidine-based solutions have been found to be more effective than povidone-iodine in reducing rates of surgical site infections (SSIs) (4). For instance, a systematic review and meta-analysis by Chen et al. concluded that chlorhexidine significantly lowers both superficial and deep SSI rates compared to povidone-iodine (5).

Globally, SSIs affect millions of hospitalized patients each year, constituting a major component of HAIs (6). Evidence suggests that many of these infections originate in operating rooms, often due to contaminated hands of surgical staff (2). Additionally, bacterial loads on hands—and under nails—can reach extremely high levels if hand hygiene is not properly performed (7).

Hand hygiene practices are influenced by a complex combination of biological, environmental, educational, and cultural factors, with habits often forming early in childhood (8). Despite the widespread publication of evidence-based hand hygiene guidelines, such as those from the WHO, compliance among healthcare personnel remains persistently suboptimal globally (9). Social cognitive models, including the Theory of Planned Behavior, have identified several key determinants that can be targeted in interventions, including knowledge gaps, perceptions, attitudes, high workload, and the accessibility of hand hygiene products (10). For instance, a recent study by Alshagrawi et al. (10) found that hand hygiene compliance rates were significantly lower among doctors (32%) compared to nurses (48%), and lower before (21%) compared to after (47%) patient interaction (10). Similarly, a study by Harun et al. (11) identified inadequate supplies, high workload, and lack of facilities as key factors contributing to low compliance (11). While the factors influencing hand hygiene in general healthcare settings are well-documented, there is a need for more focused research within the specific, high-stakes context of the operating room (OR), where team dynamics, surgical protocols, and time pressures create a unique environment. Furthermore, existing studies often focus on nurses and physicians separately, with less attention to the entire OR team, including cleaning staff. Therefore, this study aims to comprehensively assess the beliefs (attitudes) and self-reported practices of the entire OR team and to identify the key demographic and professional predictors of these outcomes. By doing so, we seek to provide targeted evidence to inform effective, role-specific interventions aimed at improving compliance and reducing infection rates in this critical setting. Additionally, we sought to evaluate compliance with the WHO's 'Five Moments for Hand Hygiene' across different demographic and professional groups.

Methods

Study Design:

This descriptive cross-sectional study was conducted over a three-month period (June-August 2022) among medical professionals working in the operating rooms of a government hospital in AlKharj, Saudi Arabia.

Study Population and Sample:

The study included physicians, nurses, and cleaning staff who were permanently assigned to the operating rooms and had at least six months of experience in their role. Temporary staff and those on leave during the data collection period were excluded. The sample size was calculated a priori using G*Power 3.1 software for a multiple linear regression analysis with 5 predictors, anticipating a medium effect size ($f^2 = 0.15$), an alpha of 0.05, and a power of 80%, which yielded a target sample of 70. A total of 78 eligible staff were invited, and 65 completed the survey, resulting in a response rate of 83.3%. Data were collected individually via a secure online survey link after obtaining informed consent. Participants who did not provide consent or who had more than 50% missing data on either the HHBS or HHPI scales were excluded from the final analysis (n=2). Of the 78 staff invited, 11 declined to participate, and 2 submitted surveys with more than 50% missing data and were excluded, resulting in a final analytical sample of 65. Participation was voluntary, and no personal information was collected. Those who did not provide informed consent or who had more than 50% missing responses were excluded.

Data Collection Tools:

The survey instrument included three main sections and was adapted from the work of Ng, Shaban, and van de Mortel (12). The first section covered demographic information such as age, gender,

educational level, occupation, work experience, and hand hygiene practices. The second section consisted of the Hand Hygiene Belief Scale (HHBS), a 23-item, five-point Likert scale designed to measure participants' attitudes and beliefs regarding hand hygiene, with higher scores indicating stronger positive beliefs. The third section included the Hand Hygiene Practice Inventory (HHPI), a 14-item, five-point Likert scale used to assess self-reported hand hygiene practices, where higher scores reflect more frequent and appropriate practices.

The Hand Hygiene Belief Scale (HHBS) and the Hand Hygiene Practice Inventory (HHPI) were initially developed by Ng, Shaban, and van de Mortel (12) to assess healthcare workers' knowledge, beliefs, and practices regarding hand hygiene. Their psychometric properties, including validity and reliability, have since been tested and confirmed in different cultural contexts. For instance, Sezen et al.(13) validated the Turkish versions of both instruments and reported high reliability coefficients, demonstrating that the HHBS and HHPI are robust and adaptable tools for cross-cultural research. The present study employed this validated English version, which was deemed appropriate for the healthcare setting where the study was conducted. The possible score ranges are 23-115 for the HHBS and 14-70 for the HHPI, with higher scores indicating stronger beliefs and better self-reported practices, respectively. For the current sample, the internal consistency was high, with a Cronbach's alpha of 0.89 for the HHBS and 0.84 for the HHPI.

A supplementary section was included to assess compliance with the World Health Organization's 'My Five Moments for Hand Hygiene' guidelines. Participants were asked to self-report their frequency of adherence (always, often, sometimes, rarely, never) for the following five moments: 1) before contact with the patient, 2) after contact with the patient, 3) after contact with the patient environment, 4) Before putting on gloves, and 5) After removing gloves. For the analysis, responses were dichotomized into 'Always Compliant' and 'Not Always Compliant'.

Data Analysis:

Data were analyzed using IBM SPSS Statistics version 29 (14). Descriptive statistics (mean, standard deviation, median, minimum, and maximum) were calculated for continuous variables, while frequencies and percentages were reported for categorical variables. The Shapiro-Wilk and Kolmogorov-Smirnov tests were applied to assess normality. For group comparisons, the Kruskal-Wallis and Mann-Whitney U tests were used. Associations between categorical demographic variables and compliance with WHO hand hygiene moments (reported as binary yes/no) were assessed using the Chi-square test (or Fisher's exact test where cell counts were <5). Relationships between continuous variables were examined using Spearman's correlation. Multiple linear regression with a backward stepwise method was conducted to identify the most parsimonious set of predictors for HHBS and HHPI scores. The assumptions of linear regression, including multicollinearity, were checked. The Variance Inflation Factor (VIF) for all predictors in the final models was below 2.0, indicating no substantial multicollinearity. Statistical significance was set at $p < 0.05$, with $p < 0.10$ considered for multiple regression models.

Ethical Approval: Permission was obtained from the author of the instrument to adopt and use it in the study. Ethical approval was obtained from the selected hospital before collecting the data. In addition to being informed about their participation, all participants (physicians, nurses, and cleaning staff) were required to provide electronic informed consent before proceeding with the survey. The data collected during the study were protected from unauthorized access. The questionnaires and other materials related to the study were coded with numbers.

Result:

Table 1 presents the sociodemographic characteristics and hand hygiene practices of the operating room staff who participated in the study (n = 65). The majority of respondents were physicians (56.9%), followed by nurses (40.0%) and a small proportion of cleaning staff (3.1%). More than half of the participants were female (55.4%), with the largest age group being those aged 21–30 years (41.5%).

In terms of educational attainment, the highest proportion held a Master's degree (35.4%), followed by those with high school (23.1%) and doctoral qualifications (21.5%). A small number reported having only primary or secondary school education (1.5%) or not attending formal education programs related to hand hygiene (13.8%).

Regarding work experience, the two largest groups were participants with 1–5 years (33.8%) and ≥16

years (33.8%) of professional experience. Most staff worked alternating day and night shifts (70.8%), while only 29.2% worked exclusively during the day. Participation in in-service training on hand hygiene varied, with 26.1% attending in-house training symposia, 21.5% attending formal symposia, and 24.6% attending medical school classes. Notably, 27.8% of participants had never received such training.

The majority of respondents self-evaluated their knowledge of hand hygiene as sufficient (86.2%), while 13.8% reported needing improvement. When asked about the products most frequently used for hand hygiene, 64.6% preferred water and soap, compared to alcohol-based sanitizers (20.0%), povidone-iodine solutions (10.8%), and chlorhexidine (4.6%). Finally, handwashing duration was most commonly reported as 15–30 seconds (60.0%), followed by >30 seconds (33.8%), with only a small proportion spending less than 15 seconds (6.2%).

Table 2 presents the descriptive statistics of participants' hand hygiene beliefs and practices (N = 65). The mean score on the Hand Hygiene Belief Scale (HHBS) was 98.70 ± 8.98, with a median of 98 and scores ranging from 68 to 139. For the Hygiene Practices Inventory (HHPI), the mean score was 83.80 ± 12.99, with a median of 86 and scores ranging from 40 to 100. Overall, participants demonstrated stronger beliefs regarding hand hygiene than their actual reported practices, as reflected by the higher HHBS scores compared to HHPI scores. Moreover, the wider variability in HHPI scores suggests that individual differences in hygiene practices were greater than in beliefs.

Table 1. Demographic and Hand Hygiene-Related Features of Surgical Staff (n = 65)

Category	**n (%)**	**Category**	**n (%)**
Gender		Job category	
Female	36 (55.4)	Doctor	37 (56.9)
Male	29 (44.6)	Nurse	26 (40.0)
		Cleaning staff	2 (3.1)
Age (years)		Employment duration	
21–30	27 (41.5)	0–2 years	17 (26.2)
31–39	17 (26.2)	3–4 years	25 (38.5)
40–49	15 (23.1)	≥5 years	23 (35.4)
≥50	7 (10.8)		
Education level		Total professional working time	
Doctorate	14 (21.5)	0–11 months	3 (4.6)
Primary/Secondary school	1 (1.5)	1–5 years	22 (33.8)
High school	15 (23.1)	6–10 years	11 (16.9)
University	12 (18.5)	11–15 years	8 (12.3)
Master's degree	23 (35.4)	≥16 years	22 (33.8)
Participation in in-service training program		Work shift	
In-house training symposium	17 (26.1)	Day shift	19 (29.2)
Symposium	14 (21.5)	Alternating day/night shift	46 (70.8)
Medical school classes	16 (24.6)		
Never received training	18(27.8)		
Self-evaluation of hand hygiene knowledge		Frequently used material for hand hygiene	
I think I need to improve	9 (13.8)	Alcohol-based sanitizer	13 (20.0)
I think it's enough	56 (86.2)	Chlorhexidine	3 (4.6)
I think it is not enough	0 (0.0)	Povidone-iodine	7 (10.8)
		Water and soap	42 (64.6)
Average time spent washing hands			
< 15 seconds	4 (6.2)		
15–30 seconds	39 (60.0)		
> 30 seconds	22 (33.8)		

Table 2. Descriptive Statistics of Hand Hygiene Beliefs and Practices (N = 65)

Scale	Mean	Median	Std. Deviation	Minimum	Maximum
Hand Hygiene Belief Scale (HHBS)	98.70	98	8.98	68.00	139.00
Hygiene Practices Inventory (HHPI)	83.80	86.00	12.99	40.00	100.00

Table 3 summarizes the distribution of hand hygiene belief (HHBS) and hygiene practice (HHPI) scores across different demographic and professional characteristics of the participants (N = 65). Overall, female participants reported slightly lower HHBS scores compared to males, but significantly higher HHPI scores ($p < 0.001$). Age showed a significant effect on belief scores ($p = 0.01$), with younger participants (21–30 years) demonstrating higher HHBS means than older groups, although no significant differences were observed for HHPI across age categories. Marital status was also associated with differences in HHBS ($p < 0.01$), with single participants scoring higher than married ones, while

Table 3. Hand Hygiene Belief and Practice Scores by Demographic and Professional Characteristics (N = 65)

	HHBS			HHPI		
	Mean ± SD	**Median**	**p-value**	**Mean ± SD**	**Median**	**p-value**
Gender						
Men	101.2 ± 17.9	99	0.270	79.8 ± 13.7	82	<0.001*
Female	97.9 ± 9.4	98		86.8 ± 11.4	89	
Age (years)						
21–30	101.5 ± 18.8	100	0.010**	85.1 ± 13.2	95	0.115
31–39	97.6 ± 10.1	97		81.3 ± 12.2	81	
40–49	96.0 ± 9.7	101		85.4 ± 12.5	86	
50 and above	99.2 ± 7.5	103		81.4 ± 14.1	83	
Marital Status						
Single	100.7 ± 18.0	101	0.008**	83.9 ± 13.2	86	0.902
Married	98.2 ± 18.7	98		84.1 ± 12.5	86	
Doctorate	97.3 ± 8.8	99		81.0 ± 13.1	83.5	
Education Level						
Primary/Secondary	113.8 ± 23.7	114	0.640	91.7 ± 10.4	92	0.018*
High school/Graduate	103.6 ± 16.2	97		87.2 ± 13.6	95	
University	97.9 ± 10.6	97		86.5 ± 12.0	91	
Master's degree	99.0 ± 6.7	98.5		82.1 ± 13.0	83	
Work Shift						
Day	100.5 ± 11.2	98	0.660	83.5 ± 14.0	87	0.755
Day/Night alternating	98.2 ± 7.5	98		84.0 ± 11.9	86	
Job Category						
Doctor	98.8 ± 7.8	99	0.230	80.9 ± 12.9	83	0.002**
Nurse	98.9 ± 10.1	98		87.7 ± 11.4	91	
Cleaning staff	105.0 ± 12.9	103		80.5 ± 14.0	80	
Employment Duration						
0–2 years	103.4 ± 12.6	102	<0.001*	84.7 ± 14.0	87	0.611
3–4 years	98.6 ± 7.3	99		83.2 ± 12.0	85	
5 years+	95.9 ± 8.2	96		83.7 ± 12.3	83	
Total Professional Working Time						
0–11 months	106.8 ± 13.5	107		83.3 ± 19.7	95	
1–5 years	101.0 ± 9.2	101	0.005**	85.5 ± 12.4	89	0.310
11–15 years	97.0 ± 8.2	98		85.6 ± 11.2	85.5	
16 years+	97.3 ± 6.5	98		83.0 ± 12.8	83	
6–10 years	98.2 ± 9.0	98		80.5 ± 12.0	79	

Footnote: Mann-Whitney U test was used for binary categories, and Kruskal-Wallis test was used for more than two categories. *p<0.001, **p<0.01, *p<0.05.

no significant difference was found for HHPI. Regarding education, participants with only primary or secondary education had the highest HHBS and HHPI scores, and the difference in HHPI across education levels reached significance ($p = 0.018$).

Job category showed a significant association with hygiene practices ($p = 0.002$), with nurses reporting higher HHPI scores compared to doctors and cleaning staff, although no significant variation was observed in HHBS. Employment duration was significantly associated with belief scores ($p < 0.001$), with participants who had less professional experience (0–2 years) scoring higher than those with longer experience. Similarly, total professional working time was associated with HHBS ($p = 0.005$), with those working 1–5 years showing higher belief scores than longer-tenured staff.

Taken together, these findings suggest that while hand hygiene beliefs were generally high across the sample, they were more strongly influenced by age, marital status, and work experience, whereas hygiene practices were more strongly associated with gender, education level, and job category.

Table 4 presents the results of a multivariate regression analysis examining the factors associated with Hand Hygiene Behavior Score (HHBS) and Hand Hygiene Practice Index (HHPI) among a sample of 65 participants. For the HHBS model, marital status and working time in the workplace emerged as significant predictors. Specifically, working time in the workplace was negatively associated with HHBS ($B = -3.372$, $p < 0.001$), indicating that participants who spent longer hours at work tended to have lower hand hygiene Behavior scores. Marital status also showed a negative, though marginally significant, effect ($B = -2.145$, $p = 0.092$), suggesting that marital status may play a modest role in shaping hygiene behaviors. The overall model explained approximately 12.2% of the variance in HHBS ($R^2 = 0.122$).

For the HHPI model, gender, education status, and hand washing time were identified as significant factors. Gender had a negative association ($B = -6.412$, $p < 0.001$), indicating that male participants had significantly lower HHPI scores than female participants (reference category).

Education status (coded ordinally from 1=Primary/Secondary to 5=Doctorate) was negatively associated with HHPI ($B = -1.985$, $p = 0.004$), this indicates that higher formal educational attainment was associated with lower self-reported hand hygiene practice scores.

In contrast, hand washing time showed a strong positive effect ($B = 7.842$, $p < 0.001$), highlighting that individuals who spend more time washing their hands tend to have better hygiene practices. This model explained a larger proportion of variance, accounting for 23.2% of HHPI ($R^2 = 0.232$).Overall, the findings underscore the importance of workplace conditions, gender, education level, and personal hygiene habits in influencing hand hygiene Behavior and practice scores.

Self-reported compliance with the WHO's 'Five Moments for Hand Hygiene' was significantly associated with job category, total professional working time, and gender, as determined by Chi-square analysis (Table 5). The results revealed that compliance before contact with the patient was significantly associated with job category ($\chi^2 = 28.914$, $p < 0.001$), professional working time ($\chi^2 = 26.872$, $p = 0.032$), and gender ($\chi^2 = 13.211$, $p = 0.008$). Similarly, compliance after contact with the patient was significantly influenced by job ($\chi^2 = 15.892$, $p = 0.015$), working time ($\chi^2 = 21.127$, $p = 0.041$), and gender ($\chi^2 = 12.984$, $p = 0.005$).

Table 4: Predictors of Hand Hygiene Behaviours and Practice Scores: Multivariate Regression Findings (n = 65)

Dependent Variable	Independent Variables	B	Std. Error	Beta	t	P
HHBS	Constant	110.321	2.480	-	44.45	<0.001*
	Marital Status	-2.145	1.295	-0.112	-1.655	0.092^{++}
	Working Time in Workplace	-3.372	0.782	-0.298	-4.314	<0.001*
	$R^2 = 0.122$					
HHPI	Constant	85.112	4.835	-	17.61	<0.001*
	Gender	-6.412	1.691	-0.247	-3.790	<0.001*
	Education Status	-1.985	0.683	-0.188	-2.906	0.004**
	Hand Washing Time	7.842	1.452	0.341	5.400	<0.001*
	$R^2 = 0.232$					

HHBS = Hand Hygiene Behaviours Score; HHPI = Hand Hygiene Practice Index. R^2 values represent the proportion of variance explained by the model. Significance levels: $p < 0.001$, $p < 0.01$, $^{++}p < 0.10$.*

Table 5: Chi-Square Analysis of Demographic Predictors of Hand Hygiene Compliance (n = 65)

Hand hygiene rule	Job (Chi-Square, df)	p-value	Total Professional Working Time (Chi-Square, df)	p-value	Gender (Chi-Square, df)	p-value
Before contact with the patient	28.914	<0.001*	26.872	0.032*	13.211	0.008**
After contact with the patient	15.892	0.015*	21.127	0.041*	12.984	0.005**
After contact with the patient environment	27.133	<0.001*	18.902	0.091	10.212	0.018^{+}
Before putting on gloves	12.215	0.142	17.564	0.327	0.834	0.927
After removing gloves	16.931	0.010*	18.043	0.115	5.721	0.121

*Chi-square test was applied. HH rules were tested across demographic groups. **$p < 0.01$, $p < 0.05$, $^{+}p < 0.10$.

Compliance after contact with the patient environment also showed significant associations with job ($\chi^2 = 27.133$, $p < 0.001$) and gender ($\chi^2 = 10.212$, $p = 0.018$), while the relationship with professional working time was marginal ($\chi^2 = 18.902$, $p = 0.091$). In contrast, compliance before putting on gloves did not show significant associations across demographic variables. For compliance after removing gloves, job category was the only significant predictor ($\chi^2 = 16.931$, $p = 0.010$), whereas no significant differences were found for working time or gender.

Overall, these findings indicate that job type and gender were the most consistent demographic predictors of hand hygiene compliance, particularly in moments of direct patient contact.

Discussion

This study assessed the hand hygiene beliefs, self-reported practices, and compliance of a multi-professional operating room team. The principal findings indicate that while beliefs regarding hand hygiene were generally strong, actual self-reported practices were more variable and consistently lower. Furthermore, our analysis identified that gender, job category, and educational level were significant predictors of hand hygiene practices, whereas professional experience and marital status were more closely associated with beliefs. Compliance with specific WHO moments was also significantly influenced by job role and gender. The following discussion interprets these key results in the context of the existing literature.

Hand hygiene is a proven, essential strategy for preventing both healthcare-associated infections (HAIs) and community-acquired illnesses.

Poor compliance with hand hygiene protocols has been linked to disturbances in hospital microbial ecosystems, increased rates of HAIs, and the spread of multidrug-resistant organisms (MROs) (e.g. improving hand hygiene adherence alone may reduce up to 50 % of pathogen transmission in healthcare settings) (15, 16). In one study of physicians, significant gender differences were found in psychosocial factors influencing hand hygiene, such as perceived barriers and motivations (17). Other research indicates that women often have higher hand hygiene knowledge and stricter hygiene norms than men (18, 19). In the current study, notable differences in compliance by gender were observed in key moments, with female participants reporting significantly higher compliance than males before and after patient contact and after touching the patient environment.

Recent research continues to confirm gender-based differences in hand hygiene compliance. For example, a 2024 study among nursing undergraduates in Saudi Arabia reported that female students demonstrated significantly better knowledge and practice of hand hygiene compared to their male peers (20). Similarly, a 2024 investigation into psychosocial determinants of hand hygiene among physicians found that men and women differed in their reported barriers: male physicians were more likely to cite reasons such as “time wasted” or “forgetting,” whereas female physicians more often mentioned skin-related discomfort (21). Among dental students, women also showed higher knowledge and better adherence to recommended practices, though in some cases the differences were not statistically significant (22). Beyond healthcare settings, large-scale field data from Swiss retail stores revealed that women were significantly more likely than men to disinfect their hands during the COVID-19 pandemic, highlighting that gender norms influence hygiene behaviors across contexts (23). These findings reinforce earlier studies by Zimmerman et al. and others, supporting the view

that male gender is a consistent risk factor for lower compliance with hand hygiene protocols (24).

Recent research confirms that hand hygiene compliance depends heavily on the clinical moment. For example, in a study in Brazil during the COVID-19 pandemic, overall compliance was only 26.5%, and compliance before touching a patient and before aseptic procedures was particularly low (3.93% and 1.88%, respectively). However, compliance rose substantially in higher-risk moments such as after exposure to bodily fluids and after patient contact (25). Another study in public hospitals in Addis Ababa, Ethiopia (26), found that 32.9% of healthcare workers always washed or sanitized their hands before clean/aseptic procedures; 73.2% always did so after exposure to body fluids. Less than half consistently complied with hand hygiene after touching patients or the patient's surroundings (26). They also reported significant associations between HHBS scores and factors such as age, length of employment, and overall professional experience. These results align closely with the findings of our study, further supporting the influence of demographic and professional characteristics on hand hygiene behavior.

In the current study, soap and water were the most frequently used method for hand hygiene; however, current evidence shows that alcohol-based hand rubs are generally more practical, highly effective, less irritating to the skin, and achieve faster reduction of microbial load (27, 28). Previous research also indicates that hand hygiene beliefs and practices tend to improve with increasing age and clinical exposure, likely due to greater awareness and accumulated experience (29, 30). Reflecting this evidence, both the World Health Organization and national guidelines recommend alcohol-based formulations as the preferred option for routine hand hygiene (31). Importantly, the risk of pathogen transmission persists even when gloves are worn, underscoring the necessity of consistent hand hygiene to prevent healthcare-associated infections, regardless of reported positive attitudes or perceived high compliance (30, 32).

Recent studies show that healthcare professionals demonstrate different patterns of hand hygiene compliance depending on their role. Physicians are more likely to perform hand hygiene before patient contact, while nurses tend to comply more often afterward (10, 33). Across all groups, glove use is often prioritized over proper hand disinfection, despite evidence that gloves do not eliminate the risk of transmission (10, 30).

Self-protection remains the strongest motivator, with the highest compliance observed after potential exposure to contamination (21, 22). Similar findings have been reported in intensive care units, where compliance is often compromised by staffing shortages, high workload, and limited resources, and where gloves are frequently misused as a substitute for hand hygiene (34, 35). To achieve sustainable improvement, strong institutional support, continuous education, and reinforcement of positive behaviors are essential (10).

Strengths and Limitations

This study has several strengths, including the use of validated instruments to measure both beliefs and practices, the inclusion of the entire OR team (physicians, nurses, and cleaning staff), and a multivariate analytical approach that identified key predictors. While this study offers insights into the hand hygiene beliefs and practices of operating room personnel, its findings should be interpreted considering several limitations.

A key limitation is the data collection method (online survey distributed via WhatsApp), which may have limited participation to those more comfortable with technology and introduced the potential for social desirability bias in self-reported practices. Furthermore, the use of convenience sampling from a single center affects the generalizability of the findings to other settings.

The cross-sectional design prevents any causal inference. Statistically, the relatively small sample size (n=65), particularly when subdivided into groups for analysis, increases the risk of Type II errors (failing to detect a true effect) and limits the stability of the regression model, despite the use of a stepwise approach and acceptable collinearity. The execution of multiple statistical comparisons also elevates the risk of Type I errors (false positives). Consequently, the findings should be interpreted as exploratory and require confirmation in larger, prospective studies. Future research would benefit from a multi-center design with a larger, randomly selected sample and direct observation of practices to provide more objective data. Furthermore, we were unable to compare participants with non- respondents, which limits our ability to fully assess potential non-response bias.

Conclusion

This study identified a dissonance between strong hand hygiene beliefs and less consistent self-reported practices among operating room staff. Key modifiable factors influencing practices included professional role (with nurses reporting higher

compliance than physicians), gender (with females reporting higher compliance), and educational level. In contrast, beliefs were more influenced by occupational tenure and marital status. These findings underscore the need for tailored, role-specific interventions that move beyond knowledge transfer to address the specific demographic and occupational determinants of behavior in the high-risk operating room environment.

Authors' contributions:

All authors contributed to the study by conceptualizing and designing the experiments, conducting the experimental work, analyzing and interpreting the data, providing necessary materials and analytical tools, and participating in the writing of the manuscript.

Acknowledgements

The author extend his appreciation to the Deanship of Scientific Research at Prince Sattam Bin Abdulaziz University for funding this research project number (PSAU/ 2025/03/35024).

Funding:

This project was supported by the Deanship of Scientific Research at Prince Sattam Bin Abdulaziz University under the research project number (PSAU/2025/03/35024).

Data availability:

Data supporting the findings of this study are available from the corresponding author on a reasonable request.

Declaration of Competence of Interest:

Authors declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References:

1. Munoz-Price LS, Bowdle A, Johnston BL, Bearman G, Camins BC, Dellinger EP, et al. Infection prevention in the operating room anesthesia work area. Infect Control Hosp Epidemiol. 2019;40(1):1–17.
2. Bali RK. Operating room protocols and infection control. In: Oral and maxillofacial surgery for the clinician. Springer; 2021. p. 173–94.
3. Silver N, Lalonde DH. Main operating room versus field sterility in hand surgery: a review of the evidence. Plastic Surgery. 2024;32(4):627–37.
4. Posso AN, Mustoe A, Neira M, Tobin M, Yamin M, Raquepo T, et al. Chlorhexidine vs. Povidone for Skin Antisepsis in Tissue Expander-Based Breast Reconstruction: A Propensity Score-Matched Analysis. J Clin Med. 2025;14(16):5734.
5. Chen S, Chen JW, Guo B, Xu CC. Preoperative antisepsis with chlorhexidine versus povidone-iodine for the prevention of surgical site infection: a systematic review and meta analysis. World J Surg. 2020;44(5):1412–24.
6. Cunha T, Miguel S, Maciel J, Zagalo C, Alves P. Surgical site infection prevention care bundles in colorectal surgery: a scoping review. Journal of Hospital Infection. 2025;155:221–30.
7. Noorani A, Rabey N, Walsh SR, Davies RJ. Systematic review and meta-analysis of preoperative antisepsis with chlorhexidine versus povidone–iodine in clean- contaminated surgery. Journal of British Surgery. 2010;97(11):1614–20.
8. Biyikoglu Alkan I, Bora Gunes N, Ozsavran M, Kuzlu Ayyildiz T. Impact of personal hygiene education based on social learning theory on preschool children. Early Child Educ J. 2025;53(2):539–50.
9. Bajunaid RM, Saeed A, Bostaji M, Farsi NJ. Hand hygiene compliance and improvement interventions in the Eastern Mediterranean Region: a systematic review and meta-analysis. Infection Prevention in Practice. 2024;6(2):100363.
10. Alshagrawi S, Alhodaithy N. Determinants of hand hygiene compliance among healthcare workers in intensive care units: a qualitative study. BMC Public Health. 2024; 24(1):2333.
11. Harun MGD, Anwar MMU, Sumon SA, Mohona TM, Hassan MZ, Rahman A, et al. Hand hygiene compliance and associated factors among healthcare workers in selected tertiary-care hospitals in Bangladesh. Journal of Hospital Infection. 2023;139:220–7.
12. Ng WK, Shaban RZ, van de Mortel TF. Development and validation of an instrument assessing healthcare workers' hand hygiene knowledge, beliefs, and practices. Infect Dis Health. 2020;25(1):43– 9.
13. Sezen AI, listed] [Additional authors as. Validity and reliability study of the Turkish versions of the Hand Hygiene Belief Scale and the Hand Hygiene Practice Inventory. Bakırköy Medical Journal. 2024;[In press].
14. George D, Mallery P. IBM SPSS statistics29 step by step: A simple guide and reference.

Routledge; 2024. Afework A, Tamene A. Uncovering the obstacles: a comprehensive analysis of barriers to hand hygiene adherence among healthcare providers: a systematic review. BMC Infect Dis. 2025;25(1):502.

15. Clancy C, Delungahawatta T, Dunne CP. Hand-hygiene-related clinical trials reported between 2014 and 2020: a comprehensive systematic review. Journal of Hospital Infection. 2021;111:6–26.
16. Park SY, Kim J, Lee E, Park S, Park JW, Yu SN, et al. Gender differences in psychosocial determinants of hand hygiene among physicians. Infect Control Hosp Epidemiol. 2024;45(2):215–20.
17. Suen LKP, So ZYY, Yeung SKW, Lo KYK, Lam SC. Epidemiological investigation on hand hygiene knowledge and behavior: a cross-sectional study on gender disparity. BMC Public Health. 2019;19(1):401.
18. Eriksson K, Dickins TE, Strimling P. Global sex differences in hygiene norms and their relation to sex equality. PLOS Global Public Health. 2022;2(6):e0000591.
19. Al-Qahtani S, al. et. Assessment of Hand-Washing Knowledge and Practice among Nursing Undergraduates in Saudi Arabia. J Nurs Educ Pract. 2024;
20. Tschudin Sutter S, al. et. Gender Differences in Psychosocial Determinants of Hand Hygiene among Physicians. Infect Control Hosp Epidemiol. 2024;
21. Group BMC MES. Handwashing Practice Among Dental Students: Lessons Unlearned from the COVID-19 Pandemic. BMC Med Educ. 2025;
22. Meier A, al. et. Large Gender and Age Differences in Hand Disinfection Behavior During COVID-19 Pandemic: Field Data from Swiss Retail Stores. arXiv Preprint. 2022;
23. Zimmerman PAP, Sladdin I, Shaban RZ, Gilbert J, Brown L. Factors influencing hand hygiene practice of nursing students: A descriptive, mixed-methods study. Nurse
24. Valim MD, Rossetto JR, Bortolini J, Educ Pract. 2020;44:102746.
25. Herwaldt L. Hand hygiene compliance in a Brazilian COVID-19 unit: the impact of moments and contact precautions. Antimicrob Resist Infect Control. 2024;13(1):7.
26. Senbato FR, Wolde D, Belina M, Kotiso KS, Medhin G, Amogne W, et al. Compliance with infection prevention and control standard precautions and factors associated with noncompliance among healthcare workers working in public hospitals in Addis Ababa, Ethiopia. Antimicrob Resist Infect Control. 2024;13(1):32.
27. Boyce JM. Current Issues in Hand Hygiene in Healthcare Settings. Curr Infect Dis Rep. 2022;24(5):81–9.
28. Organization WH. WHO Guidelines on Hand Hygiene in Health Care: 2023 Update [Internet]. World Health Organization; 2023. Available from: https://www.who.int/publications/i/item/9789240065977
29. Rahim A, al. et. Knowledge, perception, and compliance of hand hygiene among nurses: a cross-sectional study. BMC Nurs. 2021;20(1):88.
30. Kampf G. Efficacy of ethanol against viruses in hand disinfection. Journal of Hospital Infection. 2023;135:124–30.
31. Challenge FGPS. WHO guidelines on hand hygiene in health care. Retrieved from: whole-body who int/publications/009 pdf. 2009;
32. Prevention C for DC and. Core Infection Prevention and Control Practices for Safe Healthcare Delivery in All Settings [Internet]. U.S. Department of Health & Human Services; 2022. Available from: https://www.cdc.gov/infectioncontrol/guidelines/core-practices/index.html
33. Ahmadipour M, Dehghan M, Ahmadinejad M, Jabarpour M, Mangolian Shahrbabaki P, Ebrahimi Rigi Z. Barriers to hand hygiene compliance in intensive care units during the COVID-19 pandemic: A qualitative study. Frontiers in public health. 2022 Aug 18;10:968231.
34. Stein J, al. et. Hand hygiene compliance in the intensive care unit: Hand hygiene and glove changes. Am J Infect Control. 2023;51(8):931–8.
35. de Kraker ME, al. et. Hand hygiene compliance and its drivers in long-term care facilities; observations and a survey. Antimicrob Resist Infect Control. 2022;11:105.