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# Knowledge, Attitudes, and Practice of Hand Hygiene Guidelines among Health Care Providers: A National Perspective from Saudi Arabia

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## Abstract

**Background:** Given that, the majority of Health Care Associated Infections (HCAIs) are transmitted directly through the hands of healthcare providers (HCPs). Improving HCPs Hand Hygiene (HH) is a logical and cost-effective way to prevent HCAIs and restrict the transmission of microorganisms.

**Objectives:** To assess knowledge, attitudes and practice of HH guidelines, and barriers of compliance among a national sample of HCPs in Saudi Arabia.

**Methods:** Two independent national studies were conducted during approximately the same period in different health care facilities selected from each of the 20 health regions of Saudi Arabia. The first is a multicenter cross-sectional study where a total of 7,153 HCPs completed a self-administered questionnaire regarding hand hygiene. The second was an observational study of HCP's HH practices conducted using the WHO patient safety observation form. A total of 82,250 observations were made in critical care units at 268 hospitals in each region. All analyses were performed with SPSS, version 21.

**Results:** The average HH knowledge score was 65.5%; however, there were significant differences in knowledge levels across groups. Nearly all reported positive attitudes toward HH as well as adhering to the guidelines regularly. The overall observed compliance rate was 68.9% (95% CI: 67.7%-70.2%), with statistically significant variation between different departments and HCP categories, with nurses having overall higher compliance than physicians (71.9% vs. 65.7%).

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**Conclusion:** Findings indicate some gaps in HH knowledge. Further investigation is recommended into the relationship between HH compliance and actual infection rates with pre- and post-intervention measures.

**Keywords:** Hand hygiene; Healthcare providers; Knowledge; Practices; Saudi Arabia.

## 1. Introduction

Health Care associated infections (HCAIs) are ranked among the top 10 causes of hospital deaths worldwide [1]. Of every 100 hospitalized patients at any given time, 7 patients in developed countries and 10 in developing countries will acquire at least one HCAI [2]. HCAIs have a major impact on healthcare systems, affecting not only quality of care but also patient safety, with consequences including extended duration of hospital stays, increased morbidity associated with antibiotic-resistant organisms (ARO), increased risks of mortality, and a higher financial burden [3,4].

Given that the majority of HCAIs are transmitted directly through the hands of HCPs [5], improving their HH is a logical and cost-effective way to prevent HCAIs and restrict the transmission of microorganisms. It is recommended by all national and international infection control guidelines and is a basic expectation of patients and their families [6]. Unfortunately, HCP adherence to HH remains low in most healthcare settings even after educational campaigns, with compliance rates often falling below 40% globally [7].

Non-compliance with HH protocols among physicians and other HCPs are poorly understood. Studies have reported a range of barriers, including environmental (*e.g*. lack of access to sinks, difficulty locating HH products, empty dispensers, and time constraints) and personal barriers (*e.g*. attitudinal beliefs, skin irritation from repeated hand washing). Average compliance with HH recommendations varies between hospital wards, among professional categories of health-care workers, and according to working conditions, as well as according to the definitions used in different studies [8].

Physician adherence to HH was associated with the awareness of being observed, the belief of being a role model for other colleagues, a positive attitude toward HH after patient contact, and easy access to hand-rub solution. Conversely, high workload, activities associated

with a high risk for cross-transmission, and certain technical medical specialties (surgery, anesthesiology, emergency medicine, and intensive care medicine) were risk factors for nonadherence [9]. Many studies have been conducted among HCPs in Saudi Arabia to assess their knowledge, attitude, practice or adherence to HH guidelines [10–21]. All of these studies were either conducted in a single center or in multiple centers but within a single region of Saudi Arabia.

Our current study is the first nationwide study in Saudi Arabia to assess hand hygiene knowledge, attitudes, and practices, as well as assessing adherence to hand hygiene guidelines, and identifying barriers to adherence among a large randomly selected sample of HCPs representing different specialties and from different health care facilities (primary, secondary, and tertiary), including both governmental and private sector institutions.

## 2. Materials and Methods

This paper comprises analysis of data gathered during two unrelated studies concerning hand hygiene knowledge, attitudes, and practices among HCPs. The first data set is from a self-report survey conducted by the Evaluation and Impact Measurement Unit, Deputyship of Public Health, at the Saudi Ministry of Health over a period of four weeks from January-February 2018; the second data set is from an observational study conducted by the General Directorate of Infection Prevention Control (GDIPC) at the Saudi Ministry of Health over the same period. The serendipitous nature of these two coinciding and complementary national studies presented an opportunity for their respective researchers to collaborate on this joint paper in a way that would add value to both without any risk of either influencing the other's results. In fact, the cross-comparison of the self-report and observational data has added an extra dimension to the discussion and further validates the findings of each individual study.

### 2.1 Study 1: Self-Reported Knowledge and Attitudes About Hand Hygiene Guidelines

A cross-sectional study was adopted including a random nationally representative sample of HCPs (physicians, nurses, technicians, medical interns and other health specialists) from different health care facilities (primary, secondary and tertiary) – both governmental and private – from each of the 20 regions of Saudi Arabia. The sample was selected using Epi-info Stat-calc sample size calculator with a confidence level 95%, margin of error 5%, and with a conservative

estimate of the anticipated knowledge score of 50% for HCPs in each of the 20 regions. The minimum sample size required for the study was calculated to be 6,077 participants.

The study sample was selected using a stratified random sampling methodology where the study sample was stratified according to the 20 Saudi regions, then according to the type of the health care facility as follows:

1. 50% of the targeted sample were from Governmental Hospitals
2. 30% of the targeted sample were from PHCs
3. 20% of the targeted sample were from Private Hospitals

**2.1.1 Inclusion criteria:**

1. Health care professional/ service provider
2. Aged 20-60 years old
3. Males and females
4. Saudi and non-Saudi

In each health care facility, a systematic random technique was applied to select participants according to the sampling proportion. A structured self-administered questionnaire was used to collect data about HCPs knowledge regarding the procedure and importance of HH. The questionnaire was based on WHO's 2009 Knowledge and Perception Survey for HCPs [1], and was divided into three sections:

1. **Demographics**: The first section consisted of 8 demographic data questions such as region, facility, age, gender, profession, department, and duration of the respondent's work experience in their practice.
2. **Knowledge**: The second section of the questionnaire consisted of 9 questions to identify the HCPs knowledge about the "5 Moments for Hand Hygiene" and other procedures.
3. **Decision making:** The third section of the questionnaire was designed to examine respondents' decision-making processes in relation to the importance of HH and to identify their sources of knowledge and barriers to good hand hygiene practices.

Each question in section 2 aimed to assess participants' existing knowledge about different aspects of hand hygiene. The questionnaire items were based on expert consensus and were framed as questions with defined answers (either "Yes/No," or multiple choice) to facilitate self-assessment. Right answers in this section were given a score of "1" while wrong answers or

missing answers were given a score of "0." Total knowledge score was computed by adding scores of all knowledge items. Thus, the score ranged from 0 to 9. The total knowledge score was placed into three categories according to the mean knowledge score expressed as a percentage **Table (1).**

Table 1. Hand Hygiene Knowledge Score and Categories

| Category | Mean Knowledge | Average Knowledge Score | Level of Knowledge |
|---|---|---|---|
| **1.** | < 50% | Less than 4.5 | Low |
| **2.** | 50% to < 75% | 4.5 to < 6.5 | Moderate |
| **3.** | >= 75% | >= 6.5 | High |

Data entry and analysis were performed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL; version 21) software. Descriptive statistics in the form of frequency and percentage for categorical data were computed, as well as measures of central tendency (mean and median) and measures of dispersion (standard deviation and range) for continuous variables. The number and the percentage of the HCPs who gave correct and incorrect answers were reported to assess the knowledge level.

The $Chi^2$ -test was used to check if there was a significant difference between the two groups (who answered correctly and incorrectly). In terms of analytic statistics, Kolmogrov–Smirnov (K–S) test was performed for the total knowledge score to test its normal distribution. The data weren't normally distributed as evidenced by significant K–S test, so non-parametric statistical tests were applied. Mann–Whitney statistical test was utilized for comparison of two groups and Kruskal–Wallis test for comparison of more than two groups. Differences were considered as statistically significant when the p value was less than 0.05.

### 2.2 Study 2: Observed Practices of Hand Hygiene Guidelines

Hand hygiene compliance rates were collected from HCPs who work in 268 hospitals in all 20 regions at Kingdom of Saudi Arabia. The data was obtained from the critical care units (i.e. ER, ICU, and Hemodialysis) in each hospital if available

#### 2.2.1 Sampling- Inclusion Criteria

1. HCPs Staff who were available during the period of data collection.
2. HCPs who worked in ER, ICUs, Hemodialysis units.

### 2.2.2 Exclusion Criteria

1. Hospitals not affiliated to the Ministry of Health.

Observations of HCP's HH practices were conducted using the WHO patient safety observation form, during the "5 moments for hand hygiene", which are 1) Before touching a patient, 2) Before clean/ aseptic procedures, 3) After body fluid exposure risk, 4) After touching a patient, and (5) After touching patient surroundings. These observations were performed by hand hygiene coordinators, some of whom were link nurses in the same unit where observational data was being collected. Each observation, during one of the "5 moments", was recorded as one of three possible actions performed: Hand washing with soap and water, hand rubbing with an alcohol-based solution, or no hand hygiene action done. At the end of each month, observation reports were sent by each hospital to their regional Infection Prevention and Control Department, where an initial quality assessment was performed, before being submitted within 5 days to the GDIPC where a quality assessment team reviewed all reports and poor-quality reports were rejected. Observation data were collected over a period of eight weeks during January and February 2018, covering all shifts: morning, evening, and night, and covering different staff: doctors, nurses, midwifes, and other HCPs. To ensure quality of data, standardized Excel forms were used, which were closely based upon the original WHO observation form.

### 2.3 Ethical Consideration

The study was approved by the Institutional Review Board at King Fahad Medical City, Riyadh, Saudi Arabia. Consent was received from the respondents prior to administration of the questionnaire. The researcher informed participants about their right to withdraw from the study at any time without giving a reason, causing no penalty. Data gained from the study were kept in a secure place of storage only accessible by the research team.

## 3. Results

While 6077 subjects were targeted for inclusion in the self-report study (Study 1), 7153 questionnaires were adequately filled and returned. This gives a response rate of 117.7%, out of which 3659 (51.2%) were from technicians, 2111 (29.5%) were from specialists, 820 (11.5%) were from doctors, and 563 (7.8%) were from other health specialties including medical interns. Table 2 summarizes selected characteristics of the participants.

Table 2. Demographics of studied population in the Study 1 (n = 7153)

| Characteristics | Number | Percentage |
|---|---|---|
| **Gender** | | |
| Male | 2369 | 33.1 |
| Female | 4784 | 66.9 |
| **Nationality** | | |
| Saudi | 3360 | 47.0 |
| Non-Saudi | 3793 | 53.0 |
| **Profession** | | |
| Physician | 820 | 11.5 |
| Specialist | 2111 | 29.5 |
| Nurse | 94 | 1.3 |
| Technician | 3659 | 51.2 |
| Intern | 108 | 1.5 |
| Others | 361 | 5.0 |
| **Facility** | | |
| Governmental Hospital (General) | 4397 | 61.5 |
| Governmental Hospital (Specialized) | 1134 | 15.9 |
| Private hospital | 594 | 8.3 |
| Primary Health Care Center (PHC) | 1028 | 14.4 |
| **Department** | | |
| Internal medicine | 264 | 3.7 |
| Surgery | 463 | 6.5 |
| Intensive Care Unit (ICU) | 641 | 9.0 |
| Emergency Unit | 1030 | 14.4 |
| Obstetrics | 488 | 6.8 |
| Pediatrics | 392 | 5.5 |
| Physiotherapy and rehabilitation | 76 | 1.1 |
| Outpatient clinics | 745 | 10.4 |
| Others | 3054 | 42.7 |

The mean age of the respondents was 34.03± 8.6 years, and the majority of respondents were female (66.9%). The sample included Saudi HCPs (47%) as well as other nationalities (53.0%). The median duration of hospital employment was 10.1 years (range 1 to 43 years). The majority were working at governmental General Hospitals (61.5%) followed by governmental Specialized Hospitals (15.9%), PHCs (14.4%), and Private Hospitals (8.3%).

### 3.1 Hand hygiene knowledge and attitudes

The overall mean knowledge score was 5.9 (65.5%) (SD = 1.6, Range = 0-9). Although most HCPs (92.3%) reported that their knowledge of WHO recommended HH procedures was only “moderate”, the majority (71.5%) were aware that the hand washing duration recommended by WHO is from 40-60 seconds. Furthermore, HCPs also reported positive attitudes toward hand

hygiene. Most respondents (97.8%) agreed that HH is effective in preventing infection, and that it is important to hand-wash after removing examination gloves (92.3%). A similarly high proportion of HCPs were aware of the key times that hand washing is required (the WHO "5 Moments for Hand Hygiene"). The most well-known of these HH moments being before touching a patient (90.2%), and the least-known being after touching a patient's surroundings (82.3%) (Table 3).

Table 3. Knowledge and attitude of HH among HCPs in Saudi Arabia (n = 7153)

| Study variables | Number | Percentage |
|---|---|---|
| **WHO "5 Moments for HH"** | | |
| Before touching a patient | 6451 | 90.2 |
| Before clean/aseptic procedures | 5931 | 82.9 |
| After body fluid exposure/risk | 6108 | 85.4 |
| After touching a patient | 6234 | 87.2 |
| After touching patient surroundings | 5885 | 82.3 |
| **Hand washing duration recommended by WHO** | | |
| 40-60 seconds (right answer) | 5112 | 71.5 |
| **HH is effective in preventing infection** | | |
| Yes | 6997 | 97.8 |
| No | 84 | 1.2 |
| Not sure | 72 | 1.0 |
| **HH is important after removing examination gloves** | | |
| Yes | 6600 | 92.3 |
| No | 352 | 4.9 |
| Not sure | 201 | 2.8 |
| **Having a strong immune system does not reduce the importance of HH** | | |
| Yes | 6296 | 88.0 |
| No | 748 | 10.5 |
| Not sure | 109 | 1.5 |

As shown in Table 4, the highest mean HH knowledge score (on a 9-point scale) was reported among HCPs from Al-Qurayat region (7.3), while the lowest score was reported among those working in Al-Madinah and Northern Borders Regions (5.9). The difference was statistically significant.

Table 4. Mean (±SD) score of HH knowledge according to regions in Saudi Arabia (n = 7153)

| Region | Mean (±SD) score of knowledge |
|---|---|
| AlQurayat | 7.3 (1.7) |
| AlHasa | 7.0 (1.2) |
| Najran | 6.9 (1.8) |
| Taif | 6.9 (1.9) |
| Hafr Al Batin | 6.7 (0.95) |
| AlQassim | 6.5 (1.1) |
| Jaddah | 6.4 (1.3) |
| AlQunfudhah | 6.4 (1.3) |
| Makkah AlMukarramah | 6.4 (1.1) |
| Hail | 6.4 (1.0) |
| Riyadh | 6.3 (1.8) |
| Asir | 6.3 (1.2) |
| Al-Baha | 6.2 (1.5) |
| Tabuk | 6.2 (1.4) |
| Eastern Region | 6.1 (2.1) |
| Jazan | 6.1 (1.2) |
| Jouf | 6.0 (1.4) |
| Northern Borders | 5.9 (1.6) |
| Al-Madinah Al Munawarah | 5.9 (1.5) |
| Bisha | 5.7 (1.4) |

The most common sources of knowledge about HH among HCPs were HH posters (75.0%) and informational emails (74.3%), followed by knowledge shared by friends (51.2%) and lastly, training courses (39.5%).

### 3.2 Factors associated with hand hygiene knowledge

Interestingly, no correlation was found between number of years of experience as an HCP and overall knowledge about HH procedures (correlation coefficient r=0.03, p=0.82). Significant differences (p=0.00) were found in the mean knowledge of different demographics about HH, with female HCPs having overall greater mean knowledge than male HCPs (6.60 vs. 6.04) on a 9-point scale, and non-Saudi HCPs having overall greater mean knowledge of HH than Saudi HCPs (6.70 vs. 5.90). A significant difference (p=0.00) was also noted in mean knowledge of HH according to place of work (by sector), with the highest mean knowledge noted in Private Hospitals (6.80) and the lowest mean knowledge in PHCs (6.00). In addition, job classification and department were also significant factors, with nurses (6.60), physicians (6.50), and specialists (6.40) having the highest mean knowledge, and surgeons (7.60), OB/GYNs (7.10),

and ICU and internal medicine a close third place with mean knowledge of 6.70. On the lower end were job roles with presumed lower levels of direct patient contact with pharmacists and administrators scoring 5.60 and 5.70 respectively (Table 5).

Table 5. Differences in HH knowledge score across selected demographic characteristics among HCPs in Saudi Arabia (n = 7153)

| Variables | Mean (±SD) score of HH knowledge | *P*-value |
|---|---|---|
| **Gender** | | |
| Male | 6.04 (1.5) | 0.00* |
| Female | 6.6 (1.1) | |
| **Nationality** | | |
| Saudi | 5.9 (1.5) | 0.00* |
| Non-Saudi | 6.7 (0.9) | |
| **Profession** | | |
| Physician | 6.5 (1.09) | |
| Specialist | 6.4 (1.2) | 0.00* |
| Nurse | 6.6 (0.9) | |
| Technician | 6.3 (1.3) | |
| Intern | 6.2 (1.2) | |
| Health administrators | 5.7 (0.9) | |
| Pharmacists | 5.6 (1.6) | |
| **Facility** | | |
| Governmental Hospital (General) | 6.3 (1.3) | |
| Governmental Hospital (Specialized) | 6.5 (1.2) | 0.00* |
| Private hospital | 6.8 (0.9) | |
| Primary Health Care Center (PHC) | 6.0 (1.4) | |
| **Department** | | |
| Internal medicine | 6.7 (1.0) | |
| Surgery | 7.6 (1.1) | |
| Intensive Care Unit (ICU) | 6.7 (1.06) | 0.00* |
| Emergency Unit | 6.4 (1.3) | |
| Obstetrics | 7.1 (1.01) | |
| Pediatrics | 6.5 (1.16) | |
| Physiotherapy and rehabilitation | 6.1 (1.4) | |
| Outpatient clinics | 6.2 (1.3) | |

*Significant $P<0.05$.

### 3.3. Hand Hygiene Practices

A total of 82,250 hand hygiene opportunities were observed from all 268 hospitals included in the study 2. The overall compliance rate was 68.9% (95% CI: 67.7%-70.2%). Forty five percent of the observed hand hygiene opportunities were from the ER unit, which also featured the lowest compliance rate of 65.2% (95% CI: 63.7%-66.7%) compare to other units. In contrast, the HH compliance rate in the hemodialysis unit was 75.2% (95% CI: 73.2%-77.1%), ICU had 73.3 % (95% CI: 71.7%-74.9%), while other units had 67.1% (95% CI: 65.3%-68.9%); this difference was statistically significant ($p < 0.001$). Among HCP categories, the highest number of hand hygiene opportunities were observed among nurses, who had a 71.9% (95% CI: 70.5%-73.2%) compliance rate, which was higher than doctors with 65.7% (95% CI: 64.2%-67.2%); this difference was statistically significant ($p < 0.001$) (Table 6).

Table 6. Hand hygiene compliance rate in all the 20 regions at the period of January and February of 2018.

| Region | Compliance Rate |
|---|---|
| Northern Borders | 81% |
| Makkah AlMukarramah | 79% |
| Hafr Al Batin | 75% |
| Asir | 74% |
| AlHasa | 73% |
| AlBahah | 73% |
| Tabouk | 73% |
| AlQassim | 72% |
| Eastern Region | 71% |
| AlJouf | 69% |
| Hail | 69% |
| Jeddah | 69% |
| Riyadh | 69% |
| AlMedina AlMonawra | 67% |
| AlQrayat | 67% |
| AlTaif | 67% |
| Beshah | 66% |
| Najran | 64% |
| AlQunfudhah | 61% |
| Jazan | 60% |

### 3.4 Hand Hygiene Barriers

A variety of reasons were identified for HCPs lack of compliance with HH recommendations, the most commonly reported of which was lack of time, reported by 72.4% of HCPs. Other common reasons included: wearing gloves (43.3%), forgetfulness (35.6%), and skin irritation owing to frequency of hand washing (29.6%). A few HCPs (9.6%) said that they didn't possess sufficient knowledge about HH procedures, while a small minority (7.5%) actually disagreed with the WHO HH recommendations (Table 7).

Table 7. Barriers for required hand hygiene practice from perspectives of HCPs in Saudi Arabia (n = 7153)

| Barrier | Number | Percentage |
|---|---|---|
| I don't have time | 1963 | 72.4 |
| Skin irritation | 2116 | 29.6 |
| Low risk of infection from the patient | 1383 | 19.3 |
| Forgetfulness | 2543 | 35.6 |
| Don't have enough information about its importance | 687 | 9.6 |
| Not convinced of its importance | 539 | 7.5 |
| Using gloves | 3094 | 43.3 |

## 4. Discussion

Hand hygiene (hand washing with soap or alcohol-based products) is one of the most effective ways of preventing HCAI, yet the compliance rate of HCPs to WHO HH recommendations is only 38.7% on average [1]. Numerous international studies have demonstrated a correlation between a commitment to HH and level of knowledge and awareness of HCPs, among other factors, where high levels of knowledge and low overall rates of infection within hospitals are usually associated [22].

Between 2006 and 2018, a number of Saudi studies were published that aimed to assess the level of knowledge and compliance rate of HH among HCPs working in different healthcare institutions. These studies reported different levels of HH knowledge among HCPs [10–21], while one study targeting medical students actually reported a low level of knowledge [23]. This national study, combining self-report and observational data, is the first in Saudi Arabia to report, observe, and assess the level of knowledge, attitudes and practice of HH among a large

sample of HCPs randomly selected from public and private health institutions, including primary, secondary and tertiary institutions from all regions and governorates of the Kingdom of Saudi Arabia.

The overall mean HH knowledge score was moderate among HCPs in Saudi Arabia, which demonstrates the importance of education and follow-up programs, as stressed in previous local studies. Nonetheless, HCPs reported positive attitudes toward HH; they recognized its importance and were aware that having a strong immune system does not reduce the importance of HH. This finding is similar to other studies that have assessed attitudes toward HH in medical settings [20, 21].

Our study's finding of higher HH knowledge among nurses compared to other medical staff supports the findings of Van de Mortel et al. in 2010 [24], who compared HH knowledge, beliefs, and practices of nursing and medical students. They found that nursing students' HH knowledge was significantly higher than that of medical students ($p < 0.01$). This is not always the case, however, as shown by a study conducted in India by Sharma et al. [25] who reported that compliance with hand hygiene was greater among doctors (50.8%) than nurses (41.3%). Our study found that female HCPs possess overall greater mean knowledge than male HCPs. This gender difference is in line with the majority of other studies [26–28], although Zakeri et al. [29] reported no overall gender difference in HH knowledge among nurses.

The overall observed compliance rate in this study of 68.92%, is notably higher than the average international rate (38.7%) [1], but it is worth noting that it is also lower than the rate of 72.4% (95% CI: 71.0%-73.8%); reported in a previous investigation [30], which lends credence to the improved reporting standards of the current study, the strength of the quality assessment, as well as the effectiveness of ongoing training conducted in Saudi hospitals about the importance of correct documentation.

Because these two studies featured separate samples that preclude direct comparison, a number of apparent discrepancies maybe observed, which suggests areas of future studies. For example, the highest mean HH knowledge was reported in AlQurayat (81%) and Najran (77%), and yet the observed HH practice in these regions was among the lowest (67% and 64% respectively). Conversely, Northern Borders reported an overall mean knowledge score of just 66% and yet the observed compliance rate was the highest, with 81%. The latter may be

interpreted optimistically as a result of good organizational culture regarding HH among the hospitals in that region which are practiced without necessarily having the theoretical knowledge to back them up. On the other hand, we may speculate that these discrepancies reflect inaccuracies in the reporting procedure in certain hospitals.

In the present study, compliance with HH guidelines was statistically significant different between studied units. The ER units had the lowest compliance rate of 65%, whereas hemodialysis unit was 75% and ICU had 73%; the wide variation between different international studies sheds no light on these differences; however, they could be explained by a low compliance in high intensity patient care area with rapid turnover of patients such as in the ER. Nurses had the most hand hygiene opportunities observed with compliance rate higher than doctors. Pittet *et al*. [31] observed compliance of 48% and nurses had the highest hand washing adherence rates (52%), while physicians had the lowest rate (23%). In another study of the 5639 opportunities for HH, 3383 (59.9%) were properly performed and overall rates of compliance were 66.1% for doctors, 60.7% for nurses and 38.6% for paramedical staff [32].

The major limitation of this study is the cross-sectional design which limits the interpretation of the direction of the associations. Also, the sample distribution was not uniform in the field of hospital units, the main cause of which was the difference in staff numbers and also staff cooperation. On the other hand, this study had many strengths mainly the large sample of HCPs randomly selected from public and private health institutions, including primary, secondary and tertiary institutions from all regions and governorates of the Kingdom of Saudi Arabia, as well as the availability of concurrent observational data for comparison. Therefore, the finding is generalizable to the whole country.

## 5. Conclusion

Although there are gaps in HH knowledge, attitudes towards HH are positive, barriers are mainly practical issues and there is an overall willingness to improve. Consequently, both knowledge and compliance can be improved with frequent targeted educational campaigns utilizing posters and emails, supported by multiapproach training sessions, particularly in PHCs.

Concurrently, work needs to be done to reduce practical barriers. Given that physicians in an ER setting were observed to have the lowest overall HH compliance rate, possibly owing to

the rapid turnover of patients, and given that the most commonly reported reason for non-compliance is a lack of time, it is recommended to investigate policies that can facilitate increased compliance in high-pressure areas, as well as methods of incentivizing compliance which target PHCs and the ER setting specifically.

Future research in Saudi Arabia should consider change in HH knowledge, attitude and practices using interventional study design, as well as investigating the reasons behind significant regional variations. Additionally, in order to facilitate statistical analysis of correlations between self-reported knowledge and observed compliance rates, that were not possible in this study owing to incompatible samples, it may also be valuable to gather additional data for this purpose from a unified sample. Lastly, follow-up studies are recommended to measure the impact of future HH educational campaigns that include comparisons between HCAI rates and HH compliance.

## 5.1 Abbreviations

| | |
|---|---|
| ARO | Antibiotic-Resistant Organisms |
| ER | Emergency Room |
| HCAI | Health Care Associated Infection |
| HCP | Health Care Providers |
| HH | Hand Hygiene |
| ICU | Intensive Care Unit |
| PHC | Primary Health Care |
| WHO | World Health Organizations |

### 5.2 Authors Contributions

Ms. Najla Alhraiwil, Dr. Walid Al-Shroby, Dr. Samar Amer and Ms. Maram Bin Dayel contributed to the design and implementation of the research and writing of the manuscript. Ms. Razan AlYoussef and Ms. Nora AlShlash were in charge of data collection, cleaning and coding of study 1. Dr. Khalid Alanazi, Dr. Faiza AlFozan, Mr. Ali Asiri and Ms. Imtithal AlSaihati were in charge of data collection of study 2 and aided in interpreting the results and worked on the manuscript. Dr. Samar Amer performed the statistical analysis. All authors discussed the results and commented on the manuscript.

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### 5.5 Conflict of Interest Statement

The authors of this study certify that they have no conflict of interests in the subject matter or materials discussed in this manuscript.

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