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A Quasi Experiment to Implement Multimodal Strategy to Improve Hand Hygiene Behavior in a Healthcare Facility in Central Saudi Arabia

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Abstract

Background: Hand hygiene (HH) compliance of healthcare workers (HCWs) remains suboptimal despite standard multimodal promotion, and evidence for the effectiveness of novel interventions is urgently needed. **Aim:** Improve HCWs' HH compliance toward minimizing healthcare associated infection (HCAI) risk in Wadi Al Dawasir Hospital (WDH), central Kingdom of Saudi Arabia (KSA). **Methodology:** A quasi experimental approach was adopted to achieve study aim. The HCWs' behavior of HH during the duration between 2015 and 2016 was evaluated before and after a HH educational plan based on the World Health Organization (WHO) "Multimodal HH Improvement Strategy" (MMHHIS). The HCWs' compliance in response to HH indications represented by the WHO's "My 5-Moments for HH" and the type of HH action taken, whether hand washing (HW) or hand-rubbing (HR) were analyzed. **Results:** The number of opportunities observed of HH performance accounted 230 in 2015 (pre-education), and 237 in 2016 (post-education). The HCWs' HH compliance rate in the pre-education phase did not vary by the 5-moment indications [χ^2(df 4) = 0.01, p = 0.98]. Conversely, the compliance rate after HH education was higher than non-compliance across all 5-moment indication opportunities (ranged between 57.0% up to 88.9%) [χ^2(df 1) = 18.25, $p < 0.001$]. Only the 3rd and 4th 5-moment indications ("after body fluid exposure" and "after patient contact," respectively) were met with a significant HH improvement [χ^2(df 1) = 8.98, p = 0.003; and χ^2(df 1) = 16.3, $p < 0.0001$, respectively]. An overall improvement of HH compliance from 49.1% to 69.6% was significantly achieved as a result of submission to the se-

lected HH educational plan (Z = −4.38, p = 0.001). Only physicians and nurses showed a significant "within-profession" improvement in HH compliance after education, compared to that before education (Z = −3.51, p = 0.001, Z = −2.48, p = 0.013, respectively). **Conclusions:** Applying a HH education plan based on standardized multimodal HH strategy proved effective in improving the HH compliance of the hospital's staff. An ongoing observation policy within a HH-resourceful environment assures a sustainable and sound HCWs' HH behavior.

Keywords

Quasi Experiment, Multimodal Strategy, Hand Hygiene, Healthcare Facility, Central Saudi Arabia

1. Introduction

Patient safety involves a multitude of preventive standards and procedures to mitigate a myriad of risks and harmful effects upon the patients in healthcare facilities. Cross-infection at a healthcare facility, known as healthcare-associated infection (HCAI), occurs as a result of transmission of infectious agents during the course of care seeking for other conditions [1]. Largely, HCAI stands as a major safety issue, with severe and greatly underestimated effect on patients and the healthcare systems [2] [3] [4] [5]. In developed countries, the prevalence of HCAI is estimated between 5.1% and 11.6%. However, most reports of HCAI prevalence from developing countries are also above 10%. Especially riskier patients and those whose immune status is jeopardized, as in intensive care units (ICUs), neonatal ICUs (NICUs), surgical wards, and long-term care facilities (LTCU), are at a higher risk for HCAI with all the devastating health consequences [6]. The HCWs' hands have been known to be the main culprit of cross-transmission of pathogens across health facilities by touching the environment or patients' skin during care delivery [7] [8]. The mechanisms through which HCAI may be transmitted support that HH is a critical component of a bundle approaches for preventing and controlling HCAIs. The major obstacle against less risky HCAI environment is still attributed to an inconvenient HH compliance by the HCWs. Studies have reported as low less than 40% HH compliance among HCWs globally [9] [10] [11]. Lack of HH education, being a physician, working in ICUs, lack of resources for adequate HH, including HH agents and skin care products, and lack of HH performance feedback, all stand behind the high HH non-compliance trend of HCWs [10] [12] [13] [14].

The WHO First Global Patient Safety Challenge: "Clean Care is Safer Care" is an initiative aiming to strengthen international commitment to address HCAI [15]. The initiative brings together the newly developed "WHO Guidelines on HH in Healthcare" through implementation of the WHO multi-modal HH strategy in the 2009 HH technical reference manual [16]. The guidelines create a

unified description for HH methods, indications and right moments; observation process [17] [18]. The multimodal strategy encompasses conceptual and procedural elements, including: 1) system change to ensure access of HCWs to HH facilities with emphasis on availability of alcohol-based hand rub (ABHR) formulations at the point of care, 2) ongoing HH training and education, 3) evaluation of practices and feedback, 4) reminders at the workplace, and 5) providing a climate of safety through institution [16]. In practice, the WHO is determining the 5-moments for HH concept which defines key moments when HCWs should perform HH [19]. The 5-moment HH approach recommends HCWs to clean their hands, 1) before patient contact, 2) before aseptic procedure, 3) after body fluid exposure risk, 4) after patient contact, and 5) after contact with patient surroundings, as HH indications. Importantly, it has been demonstrated that the implementation of the entire WHO multimodal strategy is quite feasible and effective in enhancing HH compliance and the eventual reduction of HCAI [20] [21] [22] [23].

In the Saudi Arabian healthcare arena, there have been some studies presenting some data on HH improvement. However, most of these studies were centered on specific points of care, such as the ICU [13] [24] [25] and cardiac center [26]. A hospital-wide experiment in Makkah, west Saudi Arabia by Bukhari, *et al.* (2011) could evaluate the HH behavior among Hera hospital HCWs in most of the hospital's clinical departments [27]. We initiated this study for the implementation of WHO multimodal strategy in order to improve WDH staff awareness, compliance and correctness of HH practice, a step on the road to reduce HCAI and associated risks throughout WDH service environment. Accordingly, our goal was set as to continuously improve our HCWs' HH, aiming minimally for benchmark level of HH compliance of 70% during the first year after the education plan, with a target of 100% compliance.

2. Methodology

Wadi Al Dawasir Hospital (100 beds), is a secondary care facility with a number of subspecialties, catering for military personnel and their families. The hospital lies at Al-Dawasir valley in Najd desert within the jurisdiction of the Riyadh region, central KSA. The hospital includes over twelve standard clinical services and equipped with modern technologies. The preventive medicine department of WDH conducted a project to improve the HCWs' HH attitude among the hospital's efforts to prevent HCAI and bringing its rates to lowermost. The project extended from 2015 through 2016. The project's strategy encompassed four steps, first to identify the hospital's preparedness for sound HH trend, second to carry on baseline observation of the HCWs' HH practice, third to implement a predesigned HH intervention plan and then evaluate the HCWs' HH behavior and compliance after the intervention, fourth to assure sound and sustainable HH culture through continued follow-up and evaluation of the experiment. In preparing for the project, financial resources to furnish basic HH prac-

tice requirements were forecasted, and project's aim was related to the hospital's authority. The number and distribution of HW sinks were reviewed (one sink for each room with two beds and one sink in each isolation room), which were further equipped with un-medicated soap and paper towels. Also ABHR dispensers were located, one inside each inpatient room, one outside each room, one in each medication trolley, as well as all other points of care. All of the hospital's medical staff, including physicians, nurses, care providing technicians/auxiliary staff in the departments and outpatient service, including male, female, and pediatric wards, NICU, ICU, dental clinic, and emergency room (ER); were eligible to join the project. We implemented the WHO multimodal strategy and assessed staff's HH compliance before and after the interventions. Compliance was defined as the proportion of predefined opportunities met by HH actions (HW or HR) [17]. All five principal conceptual and procedural elements of the strategy [16] were emphasized in planning and implementing our project. The project's team encompassed two qualified infection control nurses and an infection control practitioner. In the first phase of the project (pre-intervention, 2015) we aimed to identify and observe the hospital staff's HH behavior and compliance trend. Observation included applying the WHO's direct observation method [17] using specified WHO observation form for reporting HH behavioral components. The WHO observation method is based on the 5-moments for HH indications [19]. The observation plan was based on recording the following information: 1) the indication for HH performance in accordance with the 5-moment HH opportunities, 2) compliance, whether or not HH was performed and 3) action, whether HW or HR or technique was done and the HH technique correctness. An "opportunity" for HH would be defined as the time HH should happen and it must relate to at least one HH indication (e.g., either of 5-moment of HH). Likewise, HH compliance was calculated by dividing the number of observed HH moments where proper HH was practiced by the total number of observed HH moments multiplying by 100 [28]. Hand hygiene practice of the HCWs was monitored during the daily infection control team rounds across the hospital's clinical departments. The HCWs' HH practice was observed in 30 - 45 minute sessions; no more than two HCWs would be monitored simultaneously, to assure a focused observation. In the event of the presence of time shortage of session, a limited number of HCWs in the same point of care were observed. During care sequences, the observation team was recording HH opportunities; either a positive or negative HH action would be recorded provided that it related to an indication [17]. Also during infection control rounds, if we noticed any staff with a wrongful HH practice or a low compliance, an immediate corrective training would be given on how to hygiene the hand. The second phase in 2016 started by an intensive HH education plan was conducted in the first 3 months (January through March) and was continued throughout the year. First we held an introductory workshop to all staff with participation from the hospital leaders to show the commitment. Another one-day formal training session

was performed for each department. In training, there was an emphasis on ICUs due to the critical nature of these units, and the presence of reportedly lower HH compliance rates [11] [29]. Retraining was offered throughout this phase. For instance, we took the opportunity of relevant infection prevention activities, such as the international HH day, Middle East Respiratory Syndrome coronavirus (MERS CoV) symposium, and "international patient safety goals (IPSG) workshop. Educated material included power point slides, WHO-sample video clips, printed WHO—five moments, and HH technique demonstration, and small group discussion. Important points from the WHO's HH technical reference manual on HH practice of HCWs at different clinical healthcare settings were also taught [17]. In order to keep up with the training plan and furnish HH-oriented environment in the hospital, reminders, including roll-up stands and posters with HH-promotion signs, as well as posters exhibiting the 5-moments for HH, correct HW and HR techniques, and the role of HH in preventing HCAI messages were displayed. The posted materials were placed in visible places in all points of care. The messages were changed almost on monthly basis. Each department was receiving feedback on their HH performance. During the sessions, participating HCWs were being asked to demonstrate what they have learned regarding HW/HR technique and the WHO 5-moments for HH. By the end of initial 3 months of training, all trained HCWs were considered eligible for attending to HH competency assessment; those who pass the assessment received a certificate with 1-year validity (to link to the employee's annual performance report). Two observation rounds were only carried in a day by each observer. In the wards, observing for HH actions was mostly performed at medication time, in order to save time and tackle a greater number of opportunities, (often, HCWs were mostly aware that they were monitored since they knew the infection control observation team members). In the post-education phase, there was no performance feedback during the observation rounds. All collected HH observation data were anonymous and confidential. It was difficult to tell how many times each HCW was observed during the project's life, for the same HCW most probably observed several times throughout the experiment's duration, and also that he or she would be engaged in several indications at a time. Instead, and based on the study's strategy, the type and number of opportunities were observed, during which the staff's HH compliance and action were recorded.

Study variables: The study's independent variables include the HCWs' and hospital's categorical data, such as profession, specialty, department/unit, as well as the inputs encompassed within the WHO's observation method, including the 5-moments for HH indications (before patient contact and aseptic procedure, and after body fluid exposure, patient contact and the surroundings). The principal dependent study variable was represented by the HCWs' compliance (HH "done"/"not done") with HH indications, and the secondary outcome variable was the action, which involves the type of HH response performed, whether HW

or HR. The study's outcomes would be analyzed before the educational plan (2015) and after education (2016). Since the study's philosophy was based on promoting for adopting HH by the HCWs as a hygienic behavior and a professional work style, and examining how HH training would improve such behavior, all HCWs were taken as quasi study subjects; no control group. We needed all HCWs to benefit from the experiment timely.

Statistical analysis: The collected data were entered to MS program with adequate back up, and observations made ready for statistical analysis. First, descriptive statistics, including frequency data, were displayed. The study's quantitative data were summarized as count (%). Analytical statistics mainly includes nonparametric techniques (NPMT). For instance, testing HH compliance pattern of the HCWs in response to the 5-moments for HH indications either in the pre-education phase or in the post-education phase, chi-square tests could be used. Measuring the difference in HH compliance before and after education, a repeated measure technique, such as the Wilcoxon signed ranks test, for related samples could be used. Also Wilcoxon signed ranks test could be used to measure the change in HH compliance within departments as well as within profession groups; (often, only chi-square test could be applied to measure HH compliance changes in case of unsatisfactory post-education data and corresponding pre-education compliance state (as in analyzing HH responses during individual 5 moment indications) to run repeated measure tests. Measuring the difference in compliance between professions or between departments, and also the type of H action (HW/HR), chi-square test (or Fisher's exact, where appropriate) could be used. The SPSS (Chicago, IL) software-version-20 was used for statistical analyses. Our level for tolerating type-1 error would be $\alpha = 0.05$, and results with p-value < 0.05 were considered statistically significant. A clearance from WDH Research Ethics Committee to commence the study was granted.

3. Results

As in Table 1, the HCWs' HH compliance trend before the HH education did not significantly vary by the 5-moments for HH indications. In 230 observed opportunities for a HH practice in the pre-education era, only 113 (49.1%) HH actions were done. The frequency HH was done and that HH was not done were almost equal (around 49.3% - 50.9%, both actions) [χ^2(df 4) = 0.01, p = 0.98].

The total of opportunities for HH practice accounted 230. Hand-rubbing was done more frequency than HW (57.5% vs. 42.5%), however such difference was not statistically significantly (Fisher's exact, p = 0.39, Table 1 footnote).

As in Table 2(a), only the changes in the HCWs' HH compliance before and after HH education in response to "after body fluid exposure" (from 50% to 88.9%)—and that "after patient contact" moment indications (from 50.9% to 84.7%) were statistically significant [χ^2(df 1) = 8.98, $p = 0.003$, and χ^2(df 1) = 16.3, $p < 0.0001$, respectively].

In Table 2(b), HH compliance trend of the HCWs' after HH education varied

by the variation in HH 5-moment indications. The frequency HH was done was consistently higher than that HH was not done. Out of 237 opportunities for a HH practice observed in the post-education era, 165 (69.6%) HH actions were done. Positive HH action was done most frequently after exposure to body fluids (88.9%), followed by that after patient contact (84.7%), while those before patient contact, before clean/aseptic procedure, and after contact with patient surroundings mounted 57.0%, 63.7% and 63.9% respectively) [χ^2(df 4) = 18.25, p = 0.001]. Hand-rubbing was significantly practiced more frequently than HW (58.2% vs. 41.8% (Fisher's exact = 13.1, $p < 0.0001$), (Table 2 footnote).

The overall HCWs' HH compliance rate after the education plan completion was significantly higher than the one prior to education (Z = −4.38, $p < 0.001$), (Table 3).

Table 4 displays the change in HH compliance within profession groups. Physicians and nurses were able to improve their HH compliance (+ve ranks significantly > –ve ranks), (Z = −3.51, $p < 0.0001$; Z = −2.48, $p = 0.013$, respectively), but not the technicians/auxiliary staff (Z = −1.0, $p = 0.32$).

The variation in HH compliance between professions after HH education was not statistically significant, [nurses and physicians showed an almost equal HH compliance rate: 70.3%, 69.9%, respectively, technicians/auxiliary staff least compliant (62.2%)], [χ^2(df 2) = 0.41, $p = 0.81$].

The variation in HH compliance between departments/units after HH education was statistically significant, [χ^2(df 6) = 18.76, $p = 0.005$], (Table 5(b)): female ward recorded maximum compliance rate (81.8%), followed by NICU (80.8%), male ward (78.7%), dental clinic (72.7%), and pediatric ward (62.5%). The compliance rate in the ICU and ER department was least observed (57.1%, 41.7%, respectively), (Table 5(b)).

Table 1. Pre-education HCW HH compliance by the 5-moment indications (2015).

HH compliance: pre-education					
Indication	Done*	Not done		Test statistic	*p*-value
	n (%)	n (%)	*Total* (%)		
Before patient contact	33 (49.3)	34 (50.7)	67 (100.0)		
Before clean/aseptic procedure	9 (50.0)	9 (50.0)	18 (100.0)		
After body fluid exposure	11 (50.0)	11 (50.0)	22 (100.0)	χ^2(df 4) = 0.01	0.98
After patient contact	26 (50.9)	27 (49.1)	53 (100.0)		
After contact with patient surroundings	33 (49.3)	34 (50.7)	67 (100.0)		
Total	113 (49.1)	117 (50.9)	230 100.0)		

*[HW: 48/113 (42.5%); HR: 65/113 (57.5%); Fisher's exact, $p = 0.39$].

Table 2. (a) Pre- vs. post-education compliance within each of the 5-moment indications; (b) Post-education HCW HH compliance by the 5-moment indications (2016).

(a)

Indication	*HH compliance: pre-education*			*HH compliance: post-education*			Test statistic	*p*-value
	Done	Not done	*Total* (%)	Done	Not done	*Total* (%)		
	n (%)	n (%)		n (%)	n (%)			
Before patient contact	33 (49.3)	34 (50.7)	67 (100.0)	45 (57.0)	34 (43.0)	79 (100.0)	χ^2(df 1) = 0.86	0.35
Before clean/aseptic procedure	9 (50.0)	9 (50.0)	18 (100.0)	7 (63.7)	4 (36.4)	11 (100.0)	χ^2(df 1) = 0.51	0.47
After body fluid exposure	11 (50.0)	11 (50.0)	22 (100.0)	24 (88.9)	3 (11.1)	27 (100.0)	χ^2(df 1) = 8.98	0.003
After patient contact	26 (50.9)	27 (49.1)	53 (100.0)	50 (84.7)	9 (15.3)	59 (100.0)	χ^2(df 1) = 16.3	<0.0001
After contact with patient surroundings	33 (49.3)	34 (50.7)	67 (100.0)	39 (63.9)	22 (36.1)	61 (100.0)	χ^2(df 1) = 2.8	0.09
Total	113 (49.1)	117 (50.9)	230 100.0)	165 (69.6)	72 (30.4)	237 100.0)		

(b)

Indication	*HH compliance: post-education*		*Total* (%)	Test statistic	*p*-value
	Done*	Not done			
	n (%)	n (%)			
Before patient contact	45 (57.0)	34 (43.0)	79 (100.0)		
Before clean/aseptic procedure	7 (63.7)	4 (36.4)	11 (100.0)		
After body fluid exposure	24 (88.9)	3 (11.1)	27 (100.0)	χ^2(df 4) = 18.25	0.001
After patient contact	50 (84.7)	9 (15.3)	59 (100.0)		
After contact with patient surroundings	39 (63.9)	22 (36.1)	61 (100.0)		
Total	165 (69.6)	72 (30.4)	237 100.0)		

*[HW: 69/165 (41.8%), HR: 96/165 (58.2); Fisher's exact 13.1, $p < 0.0001$].

Table 3. Healthcare workers' HH compliance during the experiment's duration (Wilcoxon signed ranks—related samples test).

Compliance		Rank			Test statistic	*p*-value
		n	Mean	Sum		
Pre-education-post-education	+ve ranks	81[b]	58.0	4698.0	Z = −4.38[d]	<0.0001
	−ve ranks	34[a]	58.0	1972.0		
	Ties	115[c]				
	Total	230				

[a]Compliance 2016 < Compliance 2015; [b]Compliance 2016 > Compliance 2015; [c]Compliance 2016 = Compliance 2015; [d] Based on positive ranks.

Table 4. Pre-education vs. post-education HH compliance trends by profession.

Difference within profession									Difference between profession				
HH compliance: post-education - pre-education									*HH compliance: post-education*				
	Rank												
Profession*	+ve		−ve		Ties	*Total*	Test statistic	*p*-value	Done	Not done	*Total*	Test statistic	*p*-value
	n	Mean	n	Mean									
Physicians	43[a]	30.0	16[b]	30.0	44[c]	103	Z = −3.51[d]	<0.0001	72 (69.9)	31 (30.1)	103		
Nurse	32[a]	24	15[b]	24	64[c]	111	Z = −2.48[d]	<0.013	78 (70.3)	33 (29.7)	111	χ^2(df 2) = 0.41	0.81
Technician	6[a]	5	3[b]	5	7[c]	16	Z = −1.0[d]	<0.32	10 (62.2)	6 (37.8)	16		
Total	81	----	34	----	115	230			160 (69.6)	70 (30.4)	230		

[a]Compliance 2016 < Compliance 2015; [b]Compliance 2016 > Compliance 2015; [c]Compliance 2016 = Compliance 2015; [d]Based on positive ranks. *Number of HH actions done within a profession not the number of the individual HCWs in the profession.

Table 5. (a) Post-education (2016) HH compliance within individual departments; (b) Post-education (2016) HH compliance between departments. (Wilcoxon signed ranks test, related samples).

(a)

HH compliance: post-education - pre-education								
	Rank							
Department	+ve		−ve		Ties	*Total*	Test statistic	*p*-value
	n	Mean	n	Mean				
ER (n = 24)	7[a]	7	6[b]	7	11[c]	24	Z = −0.28[d]	0.78
ICU	12[a]	11	9[b]	11	14[c]	35	Z = 0.65[d]	0.51
Male ward	15[a]	10	4[b]	10	28[c]	47	Z = −2.52[d]	0.012
Female ward	21[a]	12.5	3[b]	12.5	20[c]	44	Z = −3.67[d]	<0.0001
NICU	9[a]	6.5	3[b]	6.5	14[c]	26	Z = −1.73[d]	0.083
Pediatrics	12[a]	9.5	6[b]	9.5	14[c]	32	Z = −1.41[d]	0.15
Dental clinic	5[a]	4.5	3[b]	4.5	14[c]	22	Z = −0.70[d]	0.48
Total	81	----	34	-----	115	230		

[a]Compliance 2016 < Compliance 2015; [b]Compliance 2016 > Compliance 2015; [c]Compliance 2016 = Compliance 2015; [d]Based on positive ranks.

(b)

HH compliance: post-education					
Department/unit	Done	Not done	*Total*	Test statistic	*p*-value
	n (%)	n (%)	n (%)		
ER	10 (41.7)	14 (58.3)	24 (100.0)		
ICU	20 (57.1)	15 (42.9)	35 (100.0)		
Male ward	37 (78.7)	10 (21.3)	47 (100.0)		
Female ward	36 (81.8)	8 (18.2)	44 (100.0)	χ^2(df 6) = 18.76	0.005
NICU	21 (80.8)	5 (19.2)	26 (100.0)		
Pediatrics	20 (62.5)	12 (37.5)	32 (100.0)		
Dental clinic	16 (72.7)	6 (27.3)	22 (100.0)		
Total	160 (69.6)	70 (30.4)	230 (100.0)		

4. Discussion

An HCAI-free environment, mandates a prevailing sound HH culture of the healthcare facility's staff. By far, HH may well be the single most effective measure for reducing HCA rates to lowest possible [15] [16] [18] [19] [20] [30]. Such aim may only be achieved on a firm-ground HH assurance strategy implemented on an ongoing and timely-monitoring basis. In a study by Kirland and colleagues (2012) [31], the HCAI rate was reduced from 4.8 to 3.3/1000 inpatient day, after the implementation of a healthcare facility-wide HH strategy designed to improve the HCWs' HH behavior in a continuous basis. The WHO-sponsored HH multimodal strategy requires embracing certain interventional procedures, such as continuous HH education programs, and a suitable HH resource line, e.g., providing ABHRs all over the facility's floors and at all points of care [7]. A strong support and understanding from the facility's management would only render applying such strategy feasible. Meanwhile, the better structured and closely observed HH policy the higher compliance and sustainable HH practice [20] [32] [33]. On our part, the utilized WHO multimodal-based strategy was taken as a guidance to control and prevent cross-transmission of infection within WDH care environment. Findings from this research indicate that the change in the post-education compliance rate varied between low or insignificant—to satisfactory—up to high, including overall rates, compliance by the 5-moment indications, by profession and point of care, as well as HH action preference (HHW/HR). Such compliance pattern was more or less consistent with that have been found in literature.

Overall HH compliance rate: In the pre-education phase, the HCWs' HH compliance was as low as 49.1%. It seems that such low baseline compliance rate is a universal trend. Bukhari *et al.* (2011) in Saudi Arabia [27] reported a pre-training compliance rate as low as 50.3%, close to ours. Al-Tawfiq, *et al.*, (2013), [34] too found a country-wide overall pre-education compliance of 38%, a rate to improve utilizing multifaceted HH approach. In the post-education phase, we achieved a satisfactory change in HCWs' compliance from 49.1% to 69.6% past-training, [in which case, the study's objective of HH improvement was achieved, with a negligible difference (only 0.4%) from the benchmark target 70%]. In the study by Farhoudi *et al.* (2016) in Iran, [33] a sustainable improvement of HH practice of a HCWs' cohort admitted to a standardized HH improvement program was well maintained, with a notable increase of HH compliance rate from 51% to 67.2%.

HH by the 5-moment indications: In our study, only the compliance after body fluid exposure (5-moment indication 3) significantly improved from 50% up to 88.9%, as well as the compliance after patient contact (5-moment indication 4) from 50.9% to 84.7%. Most HH studies which have deployed standardized HH improvement strategies showed such partial compliance improvement in the 5-moment indications analyses. In Farhoudi *et al.* (2016), [33] experiment, the HCWs' observed HH response to "after body fluid exposure" mounted 50%

before the HH intervention but only 47.1% after the intervention. Other indications recorded an improvement in HH compliance trend with a variable a significance tendency. [33] In China, Shen and collaborates (2017) [35] also reported a partial improvement in the 5-moment HH indications response, e.g., an insignificant difference both after body fluid exposure (5-moment indication 3) (77.4% and 82.3%, $p < 0.05$), and touching patient surroundings (5-moment indication 5) (79.0% and 81.7%, $p < 0.05$), while other indications were met with a significant HH improvement tendency.

HH by profession: Hand hygiene compliance trend may vary by the HCW's individual professions. [29] [30] In our study, physicians and nurses, but not care providing technicians/auxiliary staff could achieve a significant improvement in their HH behavior as a result of joining the HH education program. On the other hand, the high HH compliance as observed during the post-education period uniformly persisted almost among all profession groups (did not statistically differ) (nurses 70.3%, physicians 69.9%, and technicians/auxiliary staff 62.2%, $p > 0.05$). Other studies reported a significantly different HH compliance rates between HCWs who had submitted to standardized HH education programs, e.g., a HH compliance rate of 82.4% for physician vs. 72.7% for nurses. [33] The Chinese experiment also reported a HH compliance rate improvement in the post-education period of 84.04% among physicians, 81.07% among nurses, and 69.4% among other professions. [35] Examining tertiary-care hospital compliance among HCWs who had been admitted to 1-year multimodal HH intervention program, Chavali *et al.* (2014) [32] in India found that only 63% of nurses adhered to HH performance, e.g., compared to 86.5% of the hospital's allied staff [32].

HH by department/unit: In our study, only in male -and female wards showed a significant improvement in the HH compliance trend as a result of the education plan. Unlike the HH performance among professions during the post-education period, the departments/units significantly varied in their HH compliance as observed during that period, e.g., female and male wards and NICU recorded maximum compliance rate ranging between 78.7% - 81.8%. The compliance in our ICU reached only 57.1% vs. 42.9% non-compliance rate, despite the HH education. In the study by Alsubaie S, *et al.* [12] to identify baseline determinants of HH compliance among 242 HCWs observed at the University Hospital in Riyadh, KSA, an overall 58% non-compliance rate in all five ICUs was reported. Being a physician and an allied health professional, as in our study, were significant non-compliance correlates. On the other hand, Al-Dorzi, *et al.* (2014) [25] revealed an overall baseline compliance of 64%, (which was lowest at night-than day shifts) at the observed ICU of a tertiary care hospital in Riyadh, KSA. The compliance improved to >80% after implementing a stepwise multifaceted and resourceful approach that included extensive education, comprehensive HH promotion material, active feedback and later universal contact precautions.

How far was the HH improvement achieved? The level for compliance with recommended HH techniques often varies between healthcare organizations; based on the quality and patient safety policy in place and the particular phases of the healthcare system's development. For instance, a national benchmark level of HH compliance among HCWs in Manitoba, Canada, was set at 70% in 2015-2016 and was increased to 75% in 2016-2017 until it reached 80% in 2017-2018 [36]. In India, Chavali *et al.* (2014) [32] reported an overall 78% compliance among the studied HCWs, a rate which was below the 90% benchmark level in critical care areas. There was also a significant predominance of HR over HW among staff (58.2% vs. 41.8%) during the post-education era. In practice, if the hands are not visibly soiled, HR is perceived by many HCWs as more practical and less time consuming than HW, meanwhile giving the same sanitizing effect. (For instance, HR for 15 seconds was found not inferior to 30 seconds in reducing bacterial counts on hands under the described experimental conditions) [37]. The higher tendency for HR among HCW populations was shown to be the favored way of HH, after intervention in the majority of points of care observed [20].

Limitations and strengths: The study scale may have been limited by the number of the observing team members, given the limited ability, e.g., to recruit some of the hospital's staff and train them to join the observation team. Having the adequate number of observers, especially at critical areas, such as the ICU, helps alleviate the remarkable non-compliance rate at such critical care point. Otherwise, the study had several strengths, adding to the findings validity and generalizability potential. First, the overall target set for HH improvement (70%) was almost accomplished (69.6%). The study adopted rigorous WHO multimodal strategy in establishing the HH project, the impact of which upon improving HH behavior among HCWs is evident. The direct observation method not only stands as a superior HH follow-up tool in the healthcare arena, but it can both determine the compliance with all 5 moments of HH and evaluate HH technique and check compliance rates according to the HCWs [31] [38].

5. Conclusion

The study aim has been achieved, using the selected study design and implementing the WHO multimodal strategy in WDH. With the intervention applied, HH compliance significantly improved. Moreover, the benchmark level (70%) for HH compliance among our HCWs was achieved. With the available resources to monitor HH adherence among WDH staff, direct observation remains our gold standard. As planned, further improvement to reach the 80% benchmark level for HH after the initial post-education year is underway. Important care areas, such as the ICU would be stressed upon to lift-up the low compliance observed in such critical point of care. A sustainable and sound HH behavior of WDH staff requires engaging each staff member in the training, so that a timely and correct HH becomes a genuine component of the quality im-

provement and safety culture of WDH personnel. As such, a multifaceted approach advocating a diversity of educational methods for a wider coverage and a better compliance, as well as an effective feedback to relate the observation outcome both to staff and WDH authority are recommended.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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