Heliyon 10 (2024) e27286

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Effectiveness of a hand hygiene training intervention in improving knowledge and compliance rate among healthcare workers in a respiratory disease hospital

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ARTICLE INFO

Keywords:
Hand hygiene training
Knowledge
Compliance
Intervention studies
Nursing staff
Practice
Bangladesh
Infection control
Hand hygiene
Cross infection
Healthcare-associated infections (HAI)

ABSTRACT

Background: Practicing hand hygiene (HH) is a crucial element of infection control, with healthcare workers (HCWs) playing a vital role in preventing the spread of infection. However, inadequate knowledge and non-compliance to HH protocols pose significant challenges in healthcare settings. This study aimed to evaluate the effectiveness of an HH training intervention in enhancing knowledge and staff compliance within a respiratory disease hospital.

Method: A pre-and post-training study was conducted among the healthcare workers in a respiratory disease treatment facility. The intervention comprised a series of 3-hour training sessions conducted over five days, focusing on the World Health Organization's (WHO) recommended guideline "Your Five Moments For Hand Hygiene." These sessions covered proper HH techniques and underscored the repercussions of inadequate compliance. Educational materials related to HH were displayed in prominent locations throughout the facility. The knowledge levels and compliance rate were assessed before and after the intervention.

Result: The intervention significantly improved HH knowledge levels and compliance rates among the participants. Marking a significant improvement, the compliance rate of HH protocols increased from 66.0% to 88.3% during the pre-to post-training period, with a concurrent increase in the mean knowledge score from 68.6% to 78.9%.

Conclusion: This study underscores the potential of training and education in elevating HH compliance and knowledge among healthcare workers. The findings advocate that healthcare facilities routinely incorporate such interventions into their infection control programs, ultimately improving patient and healthcare worker safety.

1. Background

Healthcare-associated infections (HAIs) pose a substantial threat to patients, hospital staff, and visitors alike, resulting in needless deaths, prolonged hospital stays, long-term disability, increased costs for care delivery, and the burden of antimicrobial resistance (AMR) [1]. It is a critical issue for patients in both high- and low-to middle-income countries, with an average of 7% in high-income countries and 15% in lower- and middle-income countries at risk for infection during their hospital stay and approximately 1 in 10 of

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https://doi.org/10.1016/j.heliyon.2024.e27286
Received 24 June 2023; Received in revised form 23 January 2024; Accepted 27 February 2024
Available online 4 March 2024

those affected dying from their HAI [2]. The significance of practicing effective hand hygiene (HH) becomes evident since it is considered one of the most effective ways to prevent healthcare-associated infections.

Enhancing HH practices is an integral part of infection control strategies, and the practice of HH entails cleansing hands using a hand rub comprising 60–95% alcohol content or employing soap and water, aiming to effectively minimize the presence of harmful pathogens [3,4]. As it is considered a cornerstone of infection control, research indicates that effective HH programs can prevent up to 50% of infections and yield savings of up to 16 times the implementation costs [5]. Conversely, low HH compliance accounts for up to 40% of infection transmission in healthcare facilities (HCF) [6]. Despite the importance of this practice, compliance rates at healthcare facilities remain low, with only 50% globally [7], and 9% in low-income countries [8]. This highlights the significant gap between knowledge and practice that must be addressed to improve infection control and prevent the spread of diseases.

Several factors contribute to lower compliance with HH protocols in healthcare facilities, including lack of awareness, inadequate training, and insufficient resources [9,10]. Therefore, adopting a multifaceted approach to promote HH practices is imperative, which should include raising awareness, educating and training HCWs, patients, and visitors, providing feedback, ensuring adequate resources, enforcing policies, and monitoring and evaluating the outcomes.

To promote HH practices in healthcare facilities, several organizations have developed guidelines and tools, such as the "Your Five Moments for Hand Hygiene" by the World Health Organization (WHO) [11] and the "Hand Hygiene Guidelines for Healthcare Settings" by the Centers for Disease Control and Prevention (CDC) [12]. This study evaluates the effectiveness of a training and educational intervention aimed at enhancing knowledge levels and compliance rates among healthcare workers concerning HH.

2. Methodology

2.1. Study design and setting

A pre-and post-training intervention was conducted at the Respiratory Disease Hospital in Teknaf, Cox's Bazar District, Bangladesh, which has a capacity of 65 beds. The pre-training data for assessing the knowledge level was collected between May 24, 2022, and June 05, 2022, while the post-training data was collected between February 19, 2023, and March 06, 2023. Regarding HH compliance, a pre-training observation was carried out between May 24, 2022, and June 05, 2022, and a post-training observation was conducted between February 07, 2023, and February 26, 2023. Nurses and patient care attendants in two wards of the hospital were observed using a standardized form provided by the World Health Organization (WHO) for the observation and management of HH [13]. It's worth mentioning that, given the primary focus on providing emergency services, the current field hospital omitted individual bedrooms or cabins in favor of wards. Consequently, observations in bedrooms were deemed unnecessary.

3. Training and education

A total of 47 HCWs attended the training sessions from June 6th to June 11th, 2022, which lasted for five days. Participants received training through lectures, video lessons, and practical demonstrations (washing hands with antimicrobial soap and rubbing with alcohol-based hand rub).

An infection prevention and control (IPC) team, consisting of an IPC manager and two IPC officers, conducted the training sessions for 3-hour each on the topics of the chain of infection, breaking the chain of infection, and "Your Five Moments For Hand Hygiene" suggested by the WHO for healthcare facilities. These moments include before any contact with a patient, before any aseptic tasks, after any body fluid exposure risk, after touching the patient's surroundings, and after any contact with the patient. Furthermore, educational materials, including posters outlining the Five Moments For Hand Hygiene and proper HH techniques, were strategically placed in prominent locations within wards and at handwashing stations while ensuring the HH supplies. Initiating this proactive approach facilitated easy access to this vital information for future reference. In addition, we also extended our efforts to provide patients and their attendants with advice regarding cleanliness, with a specific focus on HH. This initiative aimed to disseminate essential hygiene practices beyond healthcare staff, promoting a holistic culture of infection prevention and control within the healthcare facility.

3.1. Assessment of the knowledge

Knowledge levels were assessed through the utilization of the World Health Organization's HH knowledge questionnaire for healthcare workers [14]. This questionnaire consisted of 25 questions, with each correct answer being carried one point, and a zero for each incorrect answer. Scoring 75% or above indicates a good level of knowledge, a score between 50% and 74% is regarded as moderate, and less than 50% is considered poor level of knowledge.

4. Estimating the number of HH opportunities

Per Public Health Ontario's protocols for HH compliance and observation analysis, 56 observations, providing approximately 200 observed opportunities, were required within two weeks to assess the compliance rate in a health facility with a 100-bed capacity [15,16]. Since our facility had a 65-bed capacity, with 50 beds in regular use and the remaining 15 kept on standby for emergency diarrhoeal case management, we needed to observe 100 HH opportunities for the 50 active beds. We conducted 100 HH opportunities before training within the two-week time frame and 137 opportunities during the follow-up sessions within the same time frame. To mitigate any concerns regarding repeated observations, we meticulously scheduled the observation sessions in alignment with

healthcare providers' duty rosters. This deliberate arrangement ensured a non-repetitive representation of participants.

The overall compliance rate was calculated by dividing the number of HH actions observed by the total number of opportunities.

Ethical approval

This study has been approved by the Institutional Review Board (IRB) of the International Centre for Diarrhoeal Disease Research, Bangladesh, with the IRB approval number 00001822. Informed consent was obtained from the participants before they were asked to complete the questionnaire. The data collected was kept confidential and anonymized to ensure the participants' privacy.

4.1. Data collection and analysis

To comprehensively evaluate the intervention's impact, we gathered data from the same participants before and after the intervention. This approach facilitated a direct and in-depth comparison of their knowledge levels and HH compliance rate over time.

Knowledge data was collected through structured questionnaires developed by the World Health Organization (WHO). The questionnaire was administered online using Google Forms and distributed through email and WhatsApp to the nurses and PCAs at the hospital. To gather compliance data, a pair of infection prevention and control (IPC) officers were designated as observers, responsible for collecting HH reports within healthcare settings. Notably, the observers possessed prior experience and had undergone hands-on training in the management of Infection Prevention and Control programs, a training facilitated by the World Health Organization's local focal person. Utilizing the World Health Organization's HH observation form, we meticulously observed and captured the essential Five Moments For Hand Hygiene practice among healthcare professionals. Data from the surveys were stored and cleaned in Google Sheets and then analyzed using STATA (version 16, StataCorp LLC).

Descriptive statistics were used to determine the frequency of age, sex, and profession among nurses and PCAs, and cross-tabulation with a chi-square test was used to analyze the improvement of knowledge levels before and after training, with a p-value of <0.05 being considered statistically significant. Furthermore, a multinomial logistic regression model was applied to analyze further the relationship between the predictor variables (training status, age group, sex, and profession) and the outcome variable (knowledge level).

5. Result

47 participants, comprising 25 nurses and 22 patient care attendants, participated in this study. Prior to the training intervention, 100 HH observations were recorded, and 137 observations were recorded after implementing the intervention. Table 1 presents the sociodemographic characteristics of the participants, encompassing age, sex, and profession. The study participants had a mean age of 26.7 years, with 21.3% being under 25 and 78.7% aged $\geq$25 years old. In terms of sex, 66.0% were male, and 34.0% were female. Regarding their profession, the majority (53.2%) were nurses, while the remaining 46.8% were patient care attendants (PCAs).

Table 2 shows the frequency and percentage of correct responses for each knowledge question both before and after the training. Following the intervention, a significant improvement in HH knowledge level was observed, with the mean proportion of correct answers increasing from 68.6% to 76.9% ($p = 0.001$). Another significant improvement was noted in participants' understanding regarding appropriate times for performing HH, aiming to prevent the transmission of germs to patients ($p = 0.025$). Furthermore, participants understanding of when to perform HH actions to prevent germ spread among healthcare workers, such as after patient contact ($p = 0.022$), showed improvement.

Participants also demonstrated improved knowledge of the effectiveness of alcohol-based hand rub versus handwashing with soap and water. There was a significant increase in the percentage of correct answers for the statement "Handrubbing is more effective against germs than handwashing" ($p = 0.021$). Furthermore, the results suggest that the training had a substantial impact on the participant's attitudes toward certain practices, such as avoiding jewelry ($p = 0.000$), refraining from using artificial fingernails ($p = 0.028$), and washing hands after emptying a bedpan ($p = 0.003$). Moreover, the findings indicate that the "Good" level of HH knowledge significantly increased ($p = 0.007$) from 34% to 66% after the intervention, leading to a decrease in the "moderate" and "poor" knowledge levels.

Table 1
Distribution of participants' sociodemographic characteristics.

Variable	n (%)
Age Group (Mean ± SD = 26.7 years ± 2.96)	
<25 Years	10 (21.3)
≥25 Years	37 (78.7)
Sex	
Male	31 (66.0)
Female	16 (34.0)
Profession	
Nurse	25 (53.2)
Patient Care Attendant (PCA)	22 (46.8)

SD= Standard Deviation.

Table 2
Knowledge of HH among healthcare workers before and after training.

Questions (*Answers*)	Answered Correctly, n (%)		*P* Value
	Before Training n = 47	After Training n = 47	
1. The main route of cross-transmission of potentially harmful germs between patients in a healthcare facility? (***Healthcare workers' hands when not clean***)	26 (55.3)	28 (59.6)	NS
2. Most frequent source of germs responsible for health care-associated infections? (***Germs already present on or within the patient***)	19 (40.4)	17 (36.2)	NS
Which of the following HH actions prevents transmission of germs to the patient?			
3. Before touching a patient (***Yes***)	42 (89.4)	46 (97.9)	NS
4. Immediately after a risk of body fluid exposure (***Yes***)	39 (83.0)	38 (80.9)	NS
5. After exposure to the immediate surroundings of a patient (***No***)	2 (4.3)	9 (19.1)	0.025
6. Immediately before a clean/aseptic procedure (***Yes***)	40 (85.1)	40 (85.1)	NS
Which of the following HH actions prevents transmission of germs to the healthcare worker?			
7. After touching a patient (***Yes***)	42 (89.4)	47 (100.0)	0.022
8. Immediately after a risk of body fluid exposure (***Yes***)	41 (87.2)	41 (87.2)	NS
9. Immediately after a clean/aseptic procedure (***Yes***)	42 (89.4)	45 (95.7)	NS
10. After exposure to the immediate surroundings of a patient (***Yes***)	42 (89.4)	42 (89.4)	NS
Which of the following statements on alcohol-based handrub and handwashing with soap and water are true?			
11. Handrubbing is more rapid for hand cleansing than handwashing (***True***)	37 (78.7)	40 (85.1)	NS
12. Handrubbing causes skin dryness more than handwashing (***False***)	9 (19.1)	10 (21.3)	NS
13. Handrubbing is more effective against germs than handwashing (***False***)	29 (61.7)	39 (83.0)	0.021
14. Handwashing and handrubbing are recommended to be performed in sequence (***False***)	30 (63.8)	31 (66.0)	NS
15. What is the minimal time needed for alcohol-based handrub to kill most germs on your hands? (***20 Seconds***)	40 (85.1)	42 (89.4)	NS
Which type of HH method is required in the following situations?			
16. Before palpation of the abdomen (***Rubbing***)	32 (68.1)	35 (74.5)	NS
17.Before giving an injection (***Rubbing***)	39 (83.0)	45 (95.7)	0.045
18. After emptying a bedpan (***Washing***)	39 (83.0)	47 (100.0)	0.003
19. After removing examination gloves (***Washing***)	31 (66.0)	33 (70.2)	NS
20. After making a patient's bed (***Rubbing***)	13 (27.7)	14 (29.8)	NS
21. After visible exposure to blood (***Washing***)	47 (100.0)	47 (100.0)	NS
Which of the following should be avoided, as associated with increased likelihood of colonisation of hands with harmful germs?			
22. Wearing jewellery (***Yes***)	19 (40.4)	44 (93.6)	0.000
23. Damaged skin (***Yes***)	38 (80.9)	44 (93.6)	NS
24. Artificial fingernails (***Yes***)	35 (74.5)	43 (91.5)	0.028
25. Regular use of a hand cream (***No***)	33 (70.2)	37 (78.7)	NS
Level of Knowledge			
Good	16 (34.0)	31 (66.0)	0.007
Moderate	27 (64.3)	15 (35.7)	
Poor	04 (8.5)	01 (2.1)	
Mean Knowledge Score	47 (68.6)	47 (76.9)	0.001

NS= Not Significant.
HH= Hand Hygiene.

Results from the multinomial logistic regression model for three knowledge levels of HCWs (Good, Moderate, and Poor) are presented in Table 3, based on their training status, age, gender, and profession. The coefficient for the "after training" variable, specifically for the "Good" knowledge level, displayed a statistically significant relationship. With a coefficient of 1.36 (95% confidence interval: 0.44 to 2.28, p = 0.004), this significant finding underscores the substantial effect of training on enhancing the "Good" knowledge level. And the coefficients for profession, age, and sex for the 'Good' knowledge level are −0.73, −1.11, and 0.12, respectively. While patient care attendants and participants older than 25 years of age seem to potentially have a lower likelihood of 'Good' knowledge compared to their counterparts, females appear to have a slightly higher likelihood of achieving a 'Good'

Table 3
Multinomial logistic regression analysis for predicting training status (good vs. moderate vs. poor).

Knowledge Level	Variable	Coefficient	Standard Error	z Score	p Value	95% Confidence Interval
Good	Training Status (After Training)	1.36	0.46	2.92	0.004	(0.44–2.28)
	Age Group (>25 Years)	−1.10	0.60	−1.82	0.068	(-2.29 - 0.08)
	Sex (Female)	0.11	0.53	0.22	0.826	(-0.92 - 1.15)
	Profession (PCA)	−0.72	0.50	−1.43	0.152	−1.72 - 0.26)
Moderate	(Base outcome)					
Poor	Training Status (After Training)	−0.88	1.20	−0.74	0.460	(-3.24 - 1.46)
	Age Group (>25 Years)	15.20	2467.12	0.01	0.995	(-4820.27–4850.68)
	Sex (Female)	0.64	1.02	0.63	0.526	(-1.36 - 2.65)
	Profession (PCA)	−16.77	1976.98	−0.01	0.993	(-3891.59–3858.03)

PCA=Patient Care Attendant.

knowledge level than males. However, none of these effects are statistically significant at the 0.05 level.

Table 4 illustrates the compliance rate for HH among healthcare workers before and after intervention. Prior to the intervention, the overall compliance rate was 66.0%, which significantly increased to 88.3% after the intervention ($p = 0.001$). The compliance rate significantly improved for all HH moments ($p = 0.001$), including before touching a patient (51.2%–87.5%), before clean/aseptic procedures (42.9%–92.1%), after body fluid exposure/risk (60.0%–100%), and after touching patient surroundings (66.7%–52.9%).

6. Discussion

Emphasizing the study's context, it's vital to recognize the relatively high pre-intervention HH compliance rate and knowledge level likely influenced by the heightened awareness during the coronavirus disease 2019 (COVID-19) pandemic, resulting in a more dedicated study population. Subsequently, a significant increase in HH knowledge level from 68.6% to 76.9% ($p = 0.001$), and an overall compliance rate from 66.0% to 88.3% ($p = 0.001$) was observed following the training and education. The training modules, which were adapted from WHO's Five Moments for Hand Hygiene, have been proven effective in improving HH compliance in other regions [17]. Nevertheless, no prior research has evaluated the effectiveness of the WHO HH training module in Bangladesh's healthcare context; this study uniquely examines its effectiveness, providing valuable insights for this region.

Aligned with previous research, the current study's findings reveal increased HH knowledge. Sopjani et al. (2017) demonstrated a significant difference in knowledge ($p = 0.001$), showing a 41.6% improvement after training [18], and similarly, Afzal et al. (2019) reported a substantial knowledge increase following their educational intervention [19]. These collective outcomes demonstrate the effectiveness of HH training and educational programs in enhancing knowledge among HCWs. While these studies have indeed demonstrated the effectiveness of HH interventions, they have primarily focused on improving knowledge without delving into the nuanced differentiation of knowledge levels among these professionals. Differing from previous research, the current study uniquely contributes by employing multinomial logistic regression to analyze three distinct knowledge levels among healthcare workers, indicating a significant enhancement in the "Good" level of knowledge following the intervention. This approach allows us to discern the specific variations in knowledge improvement, providing a deeper understanding of the impact of HH training on different segments of healthcare workers. This targeted exploration of knowledge level improvement sets the current study apart and contributes to a more comprehensive understanding of the intervention's effects.

Additionally, the current study found a disparity in knowledge levels between nurses and PCAs. Nurses were found to have a greater "Good" level of knowledge than patient care attendants, which might indicate that healthcare providers with higher education and training had better knowledge and practices related to infection control. There is a possibility that HCWs with higher levels of education might have gained essential information, thus acquiring infection prevention resources [20], as the minimum education requirement for patient care attendants was a secondary school certificate or ten years of schooling, while for nurses it was a nursing diploma, that is beyond school-years than the former. Since medical doctors were not involved in the current intervention, excluding them from the study could have consequences for the findings. In some studies, doctors have exhibited different HH behaviors compared to nurses and care attendants [4]. While this study focused on nurses and patient care attendants in a field hospital context, including medical doctors in future research could provide a more comprehensive understanding of HH practices and contribute to a more well-rounded perspective on this subject.

Furthermore, gender-related differences in knowledge levels show a slight tendency for women to possess good knowledge than their counterparts, as indicated by the coefficient of 0.12 for women with a "Good" level of HH knowledge. This observation resonates with existing research suggesting that females tend to have higher health literacy and are more inclined to seek health-related information, particularly within urban settings [21]. This alignment between our findings and broader health literacy trends further reinforces the significance of considering gender-specific factors in healthcare interventions.

Revealing a substantial improvement in HH compliance, the current study shows that following the intervention, the compliance rate significantly increased by 22.3% ($p = 0.001$), underscoring the intervention's effectiveness in enhancing HH practices. A comparable study conducted in Vietnam similarly demonstrated the positive impact of a training-based intervention, with HH compliance rate rising significantly from 43.6% to 63% ($p = 0.0001$) [22]. It's essential to note that while continuous monitoring could offer a more comprehensive view, our decision to examine compliance only once after the intervention is rooted in assessing sustained behavioral change. By evaluating compliance at a single post-intervention point, we intended to capture the broader impact of the

Table 4
Comparison of HH compliance rate before and after training the HCWs.

HH Moments	Before Training		After Training		*P* value
	Opportunities observed	Action (Compliance Rate)	Opportunities Observed	Action (Compliance Rate)	
Before touching a patient	41	21 (51.2%)	16	14 (87.5%)	0.001
Before clean/aseptic procedures	7	03 (42.9%)	39	36 (92.1%)	
After body fluid exposure/risk,	5	03 (60.0%)	12	12 (100%)	
After touching a patient	29	27 (93.1%)	53	50 (94.3%)	
After touching patient surroundings	18	12 (66.7%)	17	09 (52.9%)	
Overall Compliance Rate	100	66 (66.0%)	137	121 (88.3%)	0.001

HH= Hand Hygiene.
HCWs = Healthcare Workers.

training program on healthcare staff's HH practices and knowledge levels in the long term.

Consistent with prior research, the current multifaceted approach underscores the effectiveness of hands-on training and educational materials in enhancing HH knowledge and promoting compliance across various countries [23–26]. By integrating these elements, our intervention facilitated visual and experiential learning, potentially contributing to the substantial improvement in knowledge and compliance among the nurses and PCAs.

Ongoing education and training, coupled with regular feedback and workplace reminders, have been substantiated as established strategies for perpetuating sustained adherence to HH guidelines [27,28]. As such, the challenge of sustaining enhanced HH compliance over the long term becomes evident if a consistent and ongoing endeavor is not actively pursued. As a result, it is imperative that these elements be incorporated into interventions that are perpetuated to ensure enduring positive outcomes within the healthcare environment. It is crucial to highlight that throughout the evaluation periods, daily interactions with the healthcare staff and verbal feedback were implemented as part of routine IPC activities after the intervention. The continuous reinforcement of HH protocols may have resulted in sustained adherence during the formal evaluation periods. Although periodic formal evaluations were not conducted, regular monitoring and feedback might have encouraged lasting behavioral changes among HCWs, thus strengthening its impact.

Furthermore, the present study has also demonstrated a substantial improvement of 22.3% in HH compliance rate, even after eight months following the intervention. This prolonged enhancement can be attributed to the continuous reinforcement of HH practices through daily interactions and verbal feedback during routine activities by the IPC staff. This improvement is significantly higher than the 14.5% improvement observed in another study after six months [25].

However, it is essential to note that the effectiveness of education programs in improving HH compliance may be limited by other factors, such as the availability of resources and the culture of the healthcare environment. Given the nature of the current field hospital, the relatively modest number of observations in the study may encourage a thoughtful interpretation of the results and suggest the potential for a more expansive follow-up investigation.

7. Limitation

One limitation of our study is the absence of a control group; our focus was solely on participants who received the HH intervention. While we excluded individuals not participating in the intervention from compliance assessments to maintain a clear focus on intervention impact, the need for a control group may limit our ability to compare directly against a non-intervention scenario. Besides, the study was conducted in just one respiratory disease treatment facility, which may not fully reflect other healthcare settings with different medical professionals and patients. Moreover, the Hawthorne effect may have affected the accuracy of the HH compliance rate, as participants may have altered their behavior as a result of being observed, which may lead to an overestimation of the actual compliance rate. While observers attempted to mitigate this effect by observing through natural movements and behaving as if on a normal visit, extending the observation period through a video monitoring system, which could have potentially minimized the effect, was not feasible due to concerns related to patient privacy.

8. Conclusion

In conclusion, our study fills a crucial gap in the literature by investigating the effectiveness of an HH intervention program within the unique healthcare landscape of Bangladesh. While similar research has been undertaken in other regions, our study's novelty lies in its tailored adaptation and application to the context of Bangladesh. Additionally, we have provided new insight into the impact of HH intervention through our comprehensive investigation of different levels of knowledge. Applying a multinomial logistic regression model, we uncovered insights into three distinct knowledge levels among healthcare professionals. By demonstrating the positive impact of our program, the current findings contribute localized evidence that bolsters infection prevention strategies.

Moreover, by applying the WHO standardized form for observation and management of HH, our study benefits from a robust framework, ensuring compliance with international infection prevention and control standards. While the current study reveals the post-intervention effects, we acknowledge the importance of longitudinal research to assess the sustained impact of knowledge and compliance over time. This study provides a foundation for prospective research in this area, enabling more profound insights into the enduring effects of interventions to improve HH practice. Moreover, we emphasize that a multifaceted approach is essential for sustained improvements of practices since factors such as organizational culture, product availability, and workload can all influence compliance with the HH protocols. We recommend that healthcare facilities adopt an integrated strategy encompassing training programs, regular monitoring, and ensuring a consistent supply of resources to create an environment conducive to improved practices. By synergistically integrating these elements, healthcare facilities can optimize their efforts to enhance HH practices, ultimately contributing to the prevention of infection and improved patient safety.

Data availability

Data will be made available on request.

CRediT authorship contribution statement

Samar Kishor Chakma: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software,

Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Saheen Hossen:** Validation, Resources, Data curation, Conceptualization. **Tareq Mahmud Rakib:** Validation, Supervision, Resources, Data curation, Conceptualization. **Samsul Hoque:** Validation, Resources, Data curation, Conceptualization. **Rashadul Islam:** Writing – review & editing, Validation, Formal analysis, Conceptualization. **Tapos Biswas:** Writing – review & editing, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Ziaul Islam:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Investigation. **M Munirul Islam:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

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

Acknowledgment

We express our heartfelt gratitude to the Governments of Bangladesh and Canada for their invaluable core/unrestricted support. We also extend our sincerest appreciation to all the participants who contributed to the success of this intervention. Our sincere appreciation goes to the editor and reviewers whose valuable feedback significantly contributed to improving this manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e27286.

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