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Assessment of cognitive and psychomotor domains regarding biomedical waste management and hand hygiene among various categories of health-care professionals at a tertiary care center in Northern India

Ranjana Rohilla, Puneet Kumar Gupta, Himanshu Narula, Ashok Kumar Sharma, Vibha Mehta[1], Shalinee Rao[2], Jyoti Gupta[3], Pratima Gupta

Department of Microbiology, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India, [1]Department of Virology, Institute of Liver and Biliary Sciences, New Delhi, India, [2]Department of Pathology, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India, [3]Department of Psychiatry, Dr. Yashwant Singh Parmar Medical College, Nahan, Sirmour, Himachal Pradesh, India

Address for correspondence:
Dr. Puneet Kumar Gupta, Department of Microbiology, All India Institute of Medical Sciences, Rishikesh - 249 203, Uttarakhand, India.
E-mail: drpuneetkumargupta@gmail.com

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Abstract:

BACKGROUND: Health care-associated infections (HAIs) are associated with high morbidity, mortality, and costs in the health-care sector. Large proportions of HAIs are preventable by following infection prevention activities such as hand hygiene (HH) and biomedical waste management (BMWM).

AIM: The aim was to evaluate the effectiveness of a structured teaching session on the cognitive and psychomotor domains of BMWM and HH practices in a tertiary health-care institute.

MATERIALS AND METHODS: Every participant was evaluated for pretest knowledge assessment using a prestructured format along with skill demonstration. The training included interactive sessions, open discussion, and demonstration of various skills with the active participation of various participants by trained faculty and infection control nursing officers. On completion, every participant underwent posttest evaluation.

RESULTS: During 11-month study period, 450 health-care professionals (HCPs) participated in the training program. Cognitive domain score increased from 16.3 ± 2.4 to 21.3 ± 2.0 from pre- to post-test, respectively. In psychomotor domain, pre- and post-test scores for HH were 8.3 ± 3.5 and 14.3 ± 1.4, for BMWM, the corresponding values were 8.6 ± 2.1 and 9.8 ± 0.7, respectively. Overall change in the mean (± standard deviation) score between pre- and post-test for various domains of assessment was 5.0 (±2.7), 6.0 (±3.5), 1.1 (±1.8), and 12.2 (±5.3) for knowledge, HH skill demonstration, BMW segregation skill, and cumulative assessment, respectively.

CONCLUSION: The initiation of a structured training program can result in a significant increase in participants' cognitive and psychomotor domains of learning, which may have an indirect impact on the prevention of HAIs.

Keywords:

Biomedical waste management, hand hygiene, health care-associated infections, infection control, objective structured practical examination

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Introduction

Biomedical waste management (BMWM) and hand hygiene (HH) are two crucial aspects of infection control practices in any health-care facility. Faulty practices can lead to potentially harmful consequences in the form of serious health care-associated infections (HAIs) and noninfectious injury to patients and Health Care Professionals HCPs.[1-4]

HAIs are associated with long-term morbidity, prolonged length of hospital stays, and higher mortality, further adding to financial losses for hospitals and governments.[1-3] Education and training is recommended as a core component for an effective infection prevention and control (IPC) program by the World Health Organization (WHO).[5] In general, not following effective infection control activities such as HH and BMWM relates to economic constraints on health systems in the long term. The need of the hour is capacity building by training and retraining, commitment on the part of health-care providers, and information dissemination. Many studies have highlighted the potential cost-effectiveness of reducing the incidence of HAIs by the introduction of appropriate training among frontline HCPs.[6,7]

Measures that can be taken by administration are to enforce the establishment of structured training programs for HCPs to improve their cognitive (knowledge) and psychomotor (skills) domains. Amidst a worldwide pandemic-like situation as in the case of COVID-19 in the year 2019–2020, these measures are much required to curb the transmission of infection in health-care facilities. Therefore, a structured teaching program should be in place to train HCPs quickly and efficiently.

This study aims to evaluate the effectiveness of such a well-thought-of training program focused on cognitive and psychomotor domains regarding HH and BMWM practices in a tertiary health-care institute for various categories of HCPs. Herein, we describe a standardized approach to train and evaluate its impact on the participant's cognitive and psychomotor domains of learning.

Materials and Methods

This retrospective study was conducted from January to November 2019 on combined HH and BMWM trainings. Ethical permission was obtained from the institute's ethics committee (letter no. XXXX/IEC/19/1164). These trainings were conducted in the medical education department (now called Advanced Centre of Continuous Professional Development [ACCPD]) of a tertiary care center located in Uttarakhand, India. Various formal mandatory training courses are being conducted for HCPs of different categories by ACCPD including HH and BMWM. As a part of regular skill development and enhancement, even HH and BMWM trainings are being routinely conducted in this institute from May 2017.

Each HH and BMWM course was conducted over 3 h by course coordinators from the department of microbiology and hospital's infection control team (HICT). During the start of each training program, every participant was evaluated for pretest knowledge (cognitive domain) assessment using a prestructured format (as mentioned subsequently) along with skill demonstration (psychomotor domain for HH and BMWM). The training was started with highlighting the objectives of the training followed by interactive sessions on HH and BMWM using lectures, open discussions, and demonstration of various skills with the active participation of various participants by trained faculty, and infection control nursing officers (NOs). On completion of the interactive session, every participant again underwent posttest evaluation similar to the pretest evaluation.

Knowledge assessment was done using 25 multiple-choice questions (MCQ) on various aspects of HH and BMWM. The questions for HH were adopted from the WHO HH Knowledge Questionnaire for Health-Care Workers with slight modifications.[8,9] The experts of microbiology department and ACCPD prepared questions for BMWM based on BMWM Rules-2016 by the Government of India and practical application inputs from HICT.[10] Every correct response was given a single mark with a maximum achievable score of 25 marks. Skill demonstration was assessed using objective structured practical examination (OSPE) checklist by a trainer with a maximum of 15 marks for HH and 10 for BMWM. Thus, a total maximum score of 50 was calculated by combining the marks of MCQ (maximum = 25 marks), HH skill demonstration (maximum = 15 marks), and BMWM skill demonstration (maximum = 10 marks).

A participant was considered to have completed the training successfully if his/her score was ≥40 out of 50 marks in posttest evaluation. Those participants unable to get 40 marks were called back for remediation using skill enhancement retraining on HH and BMWM. If after remediation they were unable to score ≥40 participants, they were called for next scheduled full-course retraining.

Maintaining confidentiality, all participants were categorized according to area of work, professional category, and any prior training on HH or BMWM (if prior training, then number of such prior trainings done).

- According to their area of work, participants were divided into:
  1. Medical branches – Cardiology, endocrinology, emergency medicine, gastroenterology, general medicine, nephrology, neurology, pediatric medicine, psychiatry, pulmonary medicine, physical medicine, and rehabilitation departments
  2. Surgical branches – Breast surgery; burn and plastic surgery; cardiothoracic and vascular surgery; dentistry; ear, nose, and throat; gastro-surgery; general surgery; obstetrics and gynecology; neurosurgery; ophthalmology; pediatric surgery; surgical oncology; trauma surgery; and urology departments
  3. Critical care branches (CCB) – High-dependency area of various departments, intensive care units, operation theater, transplant units, oncology, dialysis, clinical hematology, neonatology, cardiac cath laboratory, and labor room
  4. Diagnostic and laboratory branches – Pathology, microbiology, biochemistry, clinical pharmacology, neurology laboratory, molecular laboratory, nuclear medicine, transfusion medicine, and radio-diagnosis departments
  5. Other branches (OBs) – Preclinical departments, nursing college, forensic medicine, and where participants had not mentioned.
- According to designation, all participants were divided into:
  1. Resident doctors and faculty (Category I) – All resident doctors (junior residents: nonacademic or academic and senior residents) and all faculty members (assistant/associate/additional/professor)
  2. NOs (Category II) – All NO of various grades (NO Grade 1 and Grade 2, and assistant nursing superintendent) and all nursing tutors
  3. Others (Category III) – All others such as students (paramedical students of various streams, BSc nursing students, MBBS, interns, and Ph.D. students), all types of technicians, and technical assistants.

All the data were entered and analyzed using Microsoft Excel 2010 and IBM SPSS Statistics for window version 23 (IBM Corp., Armonk, N. Y., USA). Continuous data were expressed as mean ± standard deviation (SD), range, or median with interquartile range as appropriate. The normality of quantitative data was checked by measures of Kolmogorov–Smirnov tests of normality. In case of normally distributed data, independent sample *t*-test was applied. Paired sample *t*-test was performed to assess pre and post-test results in the case of continuous variables. Univariate analysis using one or two-way analysis of variance was used in the case of one or more independent variables with >2 groups against continuous dependent variables. In the case of a significant difference in groups, post hoc analysis using Tukey's test was performed. For skewed continuous variables, Mann–Whitney *U*-test/Kruskal–Wallis H-test was used. Discrete categorical data were presented as *n* (%). All statistical tests were two sided and performed at a significance level of $\alpha < 0.05$.

Results

During the 11 months of the study period, 450 participants were trained in 15 groups, with each group ranging from 13 to 45 participants (mean number/group was 30 ± 8.5). Various participants belonged to different categories of HCPs and work in the area of institution, as mentioned in Table 1. Out of the 450 participants, 109 (24.2%) had undergone prior training (median one time) for HH and/or BMWM, as shown in Table 1. The participants had an experience of work in various health-care institutions ranging from 0 to 30 years with a median of 3 years.

Details of scores during different phases of training according to the area of work and category of the profession of various HCPs are shown in Tables 2 and 3. There was a statistically significant ($P < 0.001$) increase in posttest score compared to pretest score for different domains of

Table 1: Detailed description of characteristics of the study participants

Description of characteristics	*n* (%)
Area of working and type of professional category	
Resident doctors and faculty (*n*=141 [31.3%])	
MB	23 (5.1)
CCB	26 (5.8)
SB	48 (10.7)
DB	31 (6.9)
OB	13 (2.9)
NOs (*n*=219 [48.7%])	
MB	51 (11.3)
CCB	69 (15.3)
SB	55 (12.2)
DB	2 (0.4)
OB	42 (9.3)
Others (*n*=90 [20%])	
MB	25 (5.6)
CCB	8 (1.8)
SB	10 (2.2)
DB	16 (3.6)
OB	31 (6.9)
Previous exposure to training	
Both HH and BMWM	67 (14.9)
Only HH	21 (4.7)
Only BMWM	21 (4.7)
Neither HH nor BMWM	341 (75.8)

HH=Hand hygiene, BMWM=Biomedical waste management, MB=Medical branches, CCBs=Critical care branches, SB=Surgical branches, DB=Diagnostic and laboratory braches, OB=Other branches, NO=Nursing officers

Table 2: Assessment scores for different domains of learning for various categories of health-care professionals at pre- and post-training

Learning domain and time of assessment	Mean score±SD				Significance*
	Resident doctors and faculty (Category I) (*n*=141)	Nursing officers (Category II) (*n*=219)	Others (Category III) (*n*=90)	Overall (Category I to III) (*n*=450)	
Pretest MCQ	16.7±2.1	16.3±2.3	15.7±2.9	16.3±2.4	*P*<0.05 between categories I and III only
Pretest HH OSPE	8.1±2.9	8.9±3.5	7.3±3.9	8.3±3.5	*P*<0.05 between categories II and III only
Pretest BMWM OSPE	8.0±2.2	9.6±0.7	7.3±2.9	8.6±2.1	*P*<0.05 between all[a] categories
Pretest total marks	32.9±5.0	34.8±4.6	30.2±7.6	33.3±5.7	*P*<0.05 between all[a] categories
Posttest MCQ	21.5±2.0	21.5±1.7	20.6±2.4	21.3±2.0	*P*<0.05 between categories I and III, II and III
Posttest HH OSPE	14.6±1.1	14.3±1.4	14.0±1.8	14.3±1.4	*P*<0.05 between categories I and III only
Posttest BMWM OSPE	9.8±0.5	9.9±0.2	9.4±1.2	9.8±0.7	*P*<0.05 between all[a] categories
Posttest total marks	45.8±2.4	45.8±2.3	43.9±3.5	45.4±2.7	*P*<0.05 between category I and III, II and III

*When between two categories score is having *P*<0.05 is mentioned in table and is considered significant, [a]Means I and II, I and III, II and III. SD=Standard deviation, MCQ=Multiple-choice question, HH=Hand hygiene, BMWM=Biomedical waste management, OSPE=Objective structured practical examination

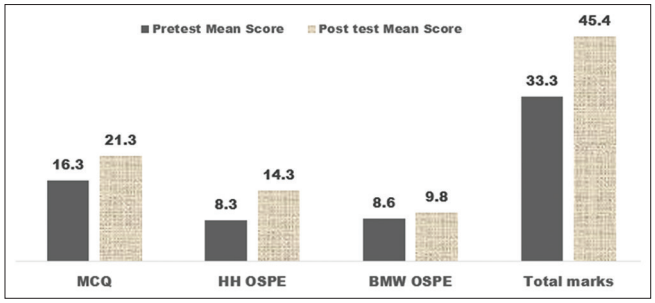

Figure 1: Overall mean score during different stages of training

learning [Figure 1 and Table 2]. Nine participants (2%) required remediation to complete the training successfully using skill enhancement retraining on HH and BMWM skills. Remediation was provided on HH or BMWM skill enhancement activity. The posttest score before and after remediation was 37.4 ± 2.0 and 41.2 ± 2.4, respectively. All the participants completed the training successfully after remediation and none required complete retraining.

The influence of prior training on - HH and BMWM management on various scores during different phases of training is shown in Table 4. An overall change in mean (±SD) score between pre-test and post-test for various domains of assessment was 5.0 (±2.7), 6.0 (±3.5), 1.1 (±1.8), and 12.2 (±5.3) for knowledge, HH skill demonstration, BMW segregation skill, and cumulative assessment, respectively.

Discussion

This formal training based on pre-/post-test evaluation model was focused on training participants on HH and BMWM practices. This sort of training evaluation is concise and draws a rational picture of improvement in learning and skill enhancement. The overall pretest mean score comprising all testing methods for all HCPs was 33.3 and the score difference among all the categories was statistically significant. The highest mean scores were obtained by NOs; this category is the one involved in maximum direct patient care, thus having more hands-on experience and better practical skills. They have their skills enhanced with regular practice and stress on practicing it strictly to prevent HAIs. Moreover, while the structured formal training started in 2019, amorphous sort of induction training was being conducted way before 2019, which could have resulted in a good pretest score for all HCPs. In addition, regular HH and BMWM audits for practice implementation were also done in various areas of hospital on a regular basis by HICT. In the case of any shortcoming, corrective measure in the form of informal need-based training is imparted by HICT immediately.

The overall mean posttest score was 45.4 as compared to 33.3 in pretest. This difference supports the achievement of the specific learning objectives of the training program. The highest posttest mean scores were attained by resident doctors, faculty, and NOs, and the score difference between Categories I and III and Categories II and III was statistically significant. As Category III includes all the students, technical staff, and assistants, it was naïve to this training aspect and moreover, they are usually not involved in providing direct patient care services. This may be the reason behind the statistically significant difference between scores of this category versus other categories.

In the pretest objective knowledge assessment, there was a statistically significant difference between the scores of Category I and III as Category I was involved in patient care as compared to Category III and they had some baseline knowledge regarding these essential aspects. In the posttest objective knowledge assessment, there was a statistically significant difference between the scores of Categories I and III and Categories II and III. After training, both Categories I and II have got higher and similar mean scores of 21.5.

In pretest HH skill demonstration, score difference was significant between Category II and Category III

Table 3: Assessment scores for different domains of learning for various health-care professionals according to area of work at pre- and post-training

Learning domain and time of assessment	Mean score±SD					Significance*
	MB (*n*=99)	CCB (*n*=103)	SB (*n*=113)	DB (*n*=49)	OB (*n*=86)	
Pretest MCQ	15.9±2.4	16.5±1.9	16.4±2.4	16.5±2.8	16.3±2.7	*P*>0.05 between all branches
Pretest HH OSPE	7.9±3.6	8.9±3.5	9.1±3.2	6.8±3.1	8.0±3.4	*P*<0.05 between branch CCB and DB, SB, and DB only
Pretest BMWM OSPE	8.3±2.5	9.3±1.3	8.9±1.9	7.7±2.6	8.3±2.0	*P*<0.05 between branch MB and CCB, CCB and DB, CCB and OB, SB and DB only
Pretest total marks	32.1±6.3	34.7±4.7	34.4±5.3	31.0±6.4	32.7±5.7	*P*<0.05 between branch MB and CCB, MB and SB, CCB and DB, SB and DB only
Posttest MCQ	21.1±2.2	21.6±1.6	21.5±1.8	21.0±2.3	21.3±2.0	*P*>0.05 between all branches
Posttest HH OSPE	14.3±1.4	14.5±1.1	14.6±1.2	14.1±1.5	14.0±1.8	*P*>0.05 between all branches
Posttest BMWM OSPE	9.7±0.8	9.9±0.3	9.9±0.4	9.5±0.8	9.7±0.9	*P*<0.05 between branch CCB and DB, SB and DB only
Posttest total marks	45.1±3.0	45.9±2.0	46.0±2.3	44.6±3.0	45.0±3.1	*P*<0.05 between branch CCB and DB, SB and DB only

*When between two branches score is having *P*<0.05, is mentioned in table and is considered significant. SD=Standard deviation, MB=Medical branches, CCB=Critical care branches, SB=Surgical branches, DB=Diagnostic and laboratory branches, OB=Others, MCQ=Multiple-choice question, HH=Hand hygiene, BMWM=Biomedical waste management, OSPE=Objective structured practical examination

Table 4: Influence of prior training on hand hygiene and biomedical waste management on various scores during different phases of training

Name of prior training	Assessment category	Had exposure to training (Yes/No)	*n*	Mean score±SD	*P*
Hand hygiene	Pretest MCQ	Yes	88	16.8±2.5	0.043
		No	362	16.2±2.4	
	Pretest HH OSPE	Yes	88	9.8±3.3	0.000
		No	362	8.0±3.4	
	Pretest total marks	Yes	88	36.0±5.2	0.000
		No	362	32.6±5.7	
	Posttest MCQ	Yes	88	21.6±1.8	0.198
		No	362	21.3±2.0	
	Posttest HH OSPE	Yes	88	14.5±1.1	0.156
		No	362	14.3±1.5	
	Posttest total marks	Yes	88	45.9±2.7	0.051
		No	362	45.3±2.7	
Biomedical waste management	Pretest MCQ	Yes	88	16.8±2.4	0.038
		No	362	16.2±2.4	
	Pretest total marks	Yes	88	35.8±4.9	0.000
		No	362	32.6±5.7	
	Pretest BMWM OSPE	Yes	88	9.4±1.2	0.000
		No	362	8.4±2.2	
	Posttest BMWM OSPE	Yes	88	9.9±0.2	0.007
		No	362	9.7±0.7	
	Posttest MCQ	Yes	88	21.9±1.6	0.002
		No	362	21.2±2.0	
	Posttest total marks	Yes	88	46.5±2.1	0.000
		No	362	45.2±2.8	

SD=Standard deviation, MCQ=Multiple-choice question, HH=Hand hygiene, BMWM=Biomedical waste management, OSPE=Objective structured practical examination

as NOs have more opportunities to practice the skill while performing activities related to patient care as compared to other HCPs not involved in routine patient care. In post-test HH skill demonstration, the mean score improved from 8.3 to 14.3 with a significant difference between Categories I and III. HH skill demonstration improved remarkably for Category I.

In pretraining BMW segregation skill demonstration, although score difference in between all the three HCP categories was statistically significant, the mean score was marginally higher for NOs followed by doctors and others. The reason could be that NOs might have induction regarding these practices because they are posted in direct patient care and waste management. Furthermore, in posttraining BMW segregation skill demonstration, score difference in between all the three HCP categories was statistically significant. The overall mean score improved from 8.6 to 9.8.

Category I received formal education in terms of theory or cognitive domain expansion with a less emphasized

scope of development of psychomotor skills. This has been previously recognized by medical education regulatory bodies in a country like India such as the "Medical Council of India (MCI).[11] Now, MCI stress on the need for the development of psychomotor domain of learning for graduate students from early part of teaching curriculum. In Category II early in course of their career as graduate student emphasis is given on patient care thus have better development of psychomotor skills. Similarly, many studies highlight the fact that NOs perform better among all HCPs regarding infection control practices.[12,13]

According to the area of work, the overall pretest mean score was highest for CCB followed by surgical, medical, and diagnostic branches. CCB have to maintain the highest standards of infection control practices to curtail infection in high-risk areas among morbidly ill patients. This might be the reason for the highest scores obtained by them. Similarly, the overall posttest mean scores were highest for CCB followed by surgical, medical, and diagnostic branches. Moreover, the overall posttest score for every category of HCPs was better than the overall pretest score, reflecting the knowledge and skill enhancement achieved from training sessions.

The effect of prior training, if any done by HCPs, was also analyzed. In HH, pretest MCQs, pretest OSPE, and overall pretest mean scores were higher for HCPs who had prior training/trainings. Regarding BMWM training, pretest and posttest scores were comparatively better for HCPS who had prior training/trainings in some form. Repeated training to some extent can have a cumulative effect on retaining facts regarding these aspects.[14]

Teaching methods play an important role in this kind of training and in the same regard, facilitator's behavior to make their teaching methods more effective is of utmost importance. In the place of controversial, traditional, didactic, teacher-centered, one-sided lectures, interactive sessions with the participants were practiced to maximize learning effectiveness. The focus was on the participant's task performance rather than just cramming facts. In addition, stress was given on task performance in naturalistic situations and the participants were encouraged to inculcate the practices in their daily professional routines. Opportunities for interaction among participants as well as between the participants and facilitator were strictly observed.[15,16]

The present study showed a remarkable impact in the form of considerable improvement in the knowledge of participants, that is, better posttest scores after the training program. This finding is consistent with a study by Gaikwad *et al*. who found a significant increase in the mean scores after educational intervention.[17] To the best of our knowledge, this is the first kind of study intended to train participants on both the standard precautions HH and BMWM simultaneously.

In addition, these trainings can encourage prompt recognition, evaluation, and management of HAIs; decrease exposures and infections among HCPs; and facilitate for effective control in the case of infectious disease outbreaks. Moreover, this is indirectly linked with long-term cost-effectiveness regarding health-care economic budgets. Training should be provided to HCPs at the time of joining, then periodically during employment, and as and when needed to address a specific need, new job profile, and last but not the least in the case of outbreak control.[1,2,18]

In the near future, one can expect the emergence of some novel infections and contagious diseases with no cure and no immunity in people worldwide. Prevention serves as the only cure as the world has seen in the case of SARS-CoV-2 pandemic in the year 2019–2020. Therefore, such training systems in place can serve as a vital strategy in fighting these diseases. The practice of HH in an appropriate manner can bring down hospital-acquired infection rate and is one of the quality indicators for International Patient Safety Goals.

The limitation of the study is that pre-/post-test usually measures students' ability to retain and recall known facts and does not necessarily indicate an improvement in real-time behavior. It stresses on the need to conduct regular audits to supervise implementation in behavioral practices. A similar study was conducted in the institute to evaluate knowledge, attitude, and compliance of HH activity on HH compliance among HCPs, which implies that sustained performance and compliance can be ensured by ongoing training.[19] Similar studies may be planned for future to measure long-term impacts of such kinds of training.

Conclusion

The initiation of such an interactive training program can result in a significant increase in participants' knowledge for all HCPs as measured by pre and post-test scores. Furthermore, there is a need to increase training opportunities in IPC to magnify the spread of training programs to reach a larger number of audiences. This approach can serve as a blueprint for other health-care institutes, where infection control activities are in the naïve phase.

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Conflicts of interest

There are no conflicts of interest.

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