Brief Report

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Evaluation of the Effectiveness and Perceived Benefits of Interventional Structured Infection Prevention and Control Training Module Introduced in the Undergraduate Medical Curricula

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Introduction: Assessing and improving infection prevention and control (IPC) knowledge and practicing skills among medical students who are the future medical practitioners is crucial for reducing the burden of healthcare-associated infections (HAIs). In this study, we assessed the IPC knowledge of undergraduate clinical-year medical students before and after interventional IPC modular training and evaluated the effectiveness and students' perception on structured modular IPC training presented to them.

Methods: This cross-sectional interventional study was conducted on single medical cohort comprising of 145 final-year undergraduate medical students of the academic year 2022-23 at COMHS. Pre-test, post-test, and feedback questionnaire were used as the assessing tools. The data were collected, entered into Excel sheet, and analyzed using SPSS software version 22. McNemar and Paired-T tests were carried out, and a P-value<0.05 was considered significant. Feedback of the questionnaire was analyzed using 3 Point Likert Scale as agree, neutral, and disagree.

Results: Overall, mean IPC knowledge scores after training (37.65±1.37) was significantly higher as compared to before training (25.13±4.51). Prior knowledge scores on certain aspects of IPC such as duration of hand washing, steps of hand washing, sequence of donning and doffing of PPE, use of N95 mask, and appropriate sharp and needle precautions, and biomedical waste management were varied from 13.6% to 65.6%. However, overall participants' knowledge (P<0.001) on these aspects increased significantly after the training. The majority of the participants (>90%) perceived IPC training as an excellent tool to improve IPC knowledge and practicing skills.

Conclusion: IPC training had a significant impact in gaining adequate IPC knowledge and practicing skills among our participants. Therefore, it is recommended that IPC training should be implemented in the undergraduate medical curriculum with greater emphasis on practicing skills.

Keywords: Hand hygiene, Healthcare, Infection, Needlestick injuries, Personal protective equipment

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Introduction

In recent years, nosocomial infections, also referred to as healthcare-associated infections (HAIs) or hospital acquired infections, have become major and serious health problems worldwide (1, 2). HAIs are defined as infections that develop in a patient 48 hours or more after hospital admission and was not present or incubating at the time of admission or within 10 days of discharge (3). Healthcare workers [HCWs] often acquire these infections or transmit infections to patients more often during healthcare delivery (3, 4). Hundreds of millions of people are affected by HAIs every year worldwide, many of which are completely avoidable (5). Approximately 5-15% of the hospitalized patients acquire new HAIs with an increased frequency among patients treated in intensive care units and 1 in 10 affected patients die of HAIs (5-8). Surgical wound infection, central line associated bacteremia, and catheter-associated urinary tract infection (CAUTI) are the frequent nosocomial infection among hospitalized patients (9, 10). Healthcare providers are the major transmitters of HAIs from one patient to another. Additionally, they are at risk of exposure to HAIs. Exposure to infectious diseases is one of the most frequently recognized occupational health hazard among HCWs (11). Moreover, the recent COVID-19 pandemic demonstrated the importance of compliance among HCWs to standard infection prevention control (IPC) guidelines recommended by World Health Organization (WHO) to protect self and others (12). IPC is an indispensable substructure of healthcare system and is defined as any policy or procedure that focuses on providing improved healthcare delivery to curtail the transmission of infections in healthcare settings (13, 14). Several factors contribute to achieving high levels of infection control measures such as enhancing knowledge, attitude, and practice about infection prevention and control among HCWs, providing Personal Protective Equipment (PPEs), conducting training workshops, and constant monitoring of HCWs' infection control practices at the workplace.

Safety of HCWs is the priority, and it necessitates healthcare professionals to have an ample knowledge concerning IPC guidelines. Health science students are exposed to hospital environment during their clinical training and are at risk of acquiring and transmitting infections (15). Therefore, early provision for IPC training to undergraduate medical students before they start their clinical training is the cornerstone to make them more knowledgeable and skillful regarding transmission of infections and ways to protect themselves and others from HAIs (15). Oman has implemented an accreditation system for medical institutions for more than a decade, and one of the assessment indicators for accreditation is patient safety in medical institution aimed at reducing the burden of HAIs (16). However, IPC training was made mandatory for all HCWs and health science students in 2021. Literature search reveals ample evidence related to assessment of knowledge, attitude, and practice (KAP) towards infection prevention and control among HCWs and health science students (15, 17-19). However, studies related to the introduction of a structured IPC training module at undergraduate level and evaluation of its impact on improving health science students' IPC knowledge and skills are limited. Hence, the current study aimed to assess the knowledge of undergraduate clinical-year medical students concerning IPC measures with a focus on standard precautions, hand hygiene, appropriate use of personal protective equipment (PPE) including donning and doffing, respiratory hygiene and cough etiquette, safe sharp and needle precautions, and biomedical waste management. Subsequently, we provided hands-on experience through modular IPC training program by Ministry of Health (MOH), Oman accredited hospital infection control team and evaluated its effectiveness in enhancing participants' IPC knowledge and skills.

Methods

The current cross-sectional interventional study evaluated the efficacy of a structured IPC training module in enhancing the participants' knowledge on infection prevention strategies as well as perception of modular IPC training conducted at COMHS in collaboration with Infection control team of Ministry of Health, Oman. The study was approved by Institutional Ethic and Review committee [Approval number: NU/COMHS/EBC0029/2022], College of Medicine and Health Sciences (COMHS), National University, Oman. COMHS follows six-year undergraduate medical program (MD1 to MD6); MD1 and MD2, MD3 and MD4, and MD5 and MD6 are categorized as premedical, preclinical, and clinical years, respectively. By convenience sampling technique, the cohort of clinical-year (MD6) undergraduate medical students were included as study participants. There were 145 eligible students in MD6. All students were explained about the purpose and benefits of the study.

Inclusion criteria: All MD6 students who

gave written informed consent to participate and completed all the components of the study were included in the study.

Exclusion criteria: All MD6 students who were unwilling and those who participated but missed one or more components of the study or with incomplete data were excluded from the study.

Study design: Figure 1 represents the flow chart of the study design. A modified pre-test and post-test questionnaire, pre-validated and tested by infection control experts and microbiologists for content and reliability was used for assessing the knowledge and attitude of IPC among participants. The pilot study was conducted on 10% of the clinical year students of different batches to ensure the content of the instrument after face validity was ensured by senior colleagues (n=3). We conducted a statistical analysis of the construct validity of the individual items of the tool using the Pearson correlation coefficient; we found a statistically significant correlation. Cronbach's alpha coefficients of 0.81, 0.83, and 0.84, respectively, indicate that the items of the tool are reliable. Pre-test and the post-test were comprised of questions on IPC knowledge such as hand hygiene, isolation precautions, Personal Protective Equipment (PPE), respiratory hygiene, cough etiquette, safe sharp and needle precautions, biomedical waste management, and Oman's HCWs vaccination guidelines. Pre-test was administered through online Google form. Responses were collected from the participants. The next day, structured educational training on IPC was delivered to participants by Ministry of Health (MOH), Oman accredited infection control experts through combination of didactic lectures, simulation, and practical demonstration of skills. Improvement in knowledge and correct practicing skills of IPC such as hand hygiene, donning and doffing of PPE, respiratory and cough etiquette, needle-stick precautions, and biomedical waste management by students was assessed through post-test and individual student's demonstration of skills in the presence of infection control experts. Finally, an anonymous pre-determined self-administered questionnaire feedback was administered through online Google form to evaluate the students' perception on the effectiveness of IPC modular training in enhancement of their IPC knowledge and practicing skills.

Data collection and data management

The pre-test, post-test, and feedback data were collected, entered into Excel sheet, matched by the respondent, cleaned for errors, and utilized for statistical analysis. For all pre-test and post-test sections, a correct response of each categorical variable was scored 1 and incorrect response was scored 0.

Statistical analysis

Statistical Package for the Social Sciences version 22 was used for statistical analysis. The total and section scores were calculated before and after the intervention to ascertain the quantitative impact on students' performance. Paired T-tests were applied to find the statistical significance

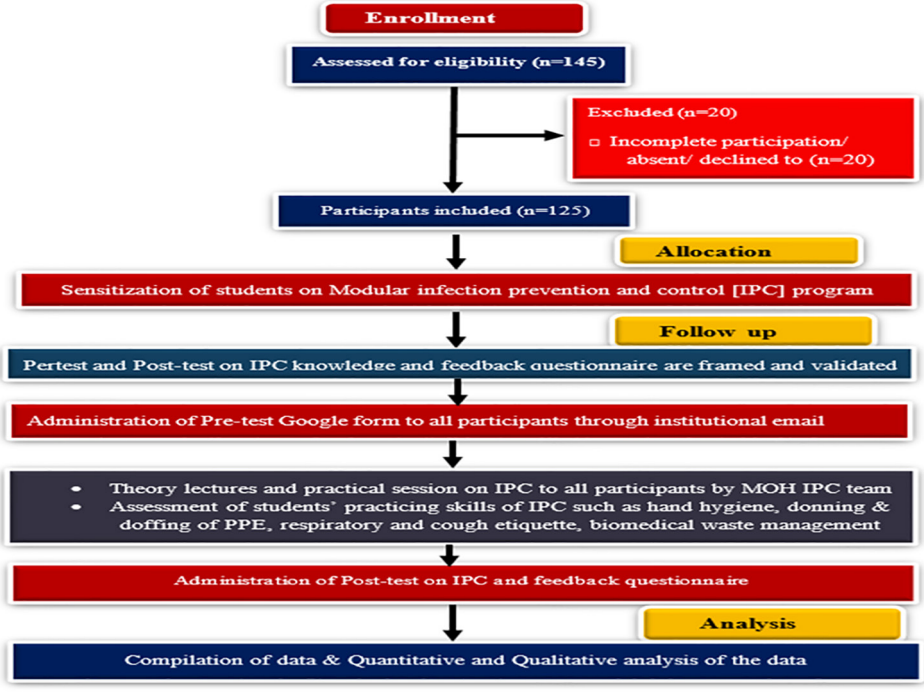

Figure 1: Consort flow chart of the study design

between means and standard deviations, and pair-wise analysis for categorical responses were carried out using McNemar test. P-value<0.05 was considered as significant.

Results

In total, 125 participants were included in the study after applying inclusion and exclusion criteria. Table 1 shows that the overall mean knowledge scores after training (37.65±1.37) were significantly higher compared to before the training (25.13±4.51, P<0.001).

Tables 2 and 3 display knowledge scores of each item of IPC. 113 (90.4%) out 125 participants agreed that the primary goal of standard precaution was to reduce infection even before the intervention. In the section of hand hygiene, the least correctly answered questions before training were related to the duration of hand washing with soap and water (45.6%), alcohol-based hand rub (52.8%), and correct sequence of hand washing (61.6%). With respect to knowledge about 5 moments of hand hygiene, only 66.4% answered that hand washing was necessary after touching the patient's surrounding. In the section on PPE, the least correct responses were received for questions pertaining to correct sequence of donning (46.4%) and doffing (13.6%) of PPEs. The correct responses to questions on respiratory hygiene and cough etiquette varied between 44% and 74%, with only 44% participants knowing the difference between airborne and droplet infection. Lastly, prior knowledge related to sharp and needle precautions and biomedical waste management was inadequate, with less than 50% correct responses to questions on "do not recap the needle after withdrawing blood (43.2%), mutilate the needle after use (40.8%), discard all infectious waste to yellow-coded container (44.8%), and disinfection of the surface contaminated with blood spillage with sodium hypochlorite (38.4%)". Knowledge scores for all items of IPC after the intervention varied between 86% and 100%.

Figure 2 shows the students' opinion on IPC training session. The majority of our participants (>90%) expressed that IPC training improved their knowledge and practicing skills such as correct steps of hand hygiene technique and wearing personal protective equipment including donning and doffing of PPE. More than 80% of the students suggested such training sessions should be held every year and preferably be initiated in preclinical years.

Discussion

Workplace health and safety to protect HCWs and patients is one of the topmost priorities in the present times of high prevalence of HAIs and antimicrobial resistance (20). Health science students are at risk of exposure to HAIs early in their professional career. Therefore, it is crucial to assess and strengthen the students' IPC knowledge and practicing skills through an effective educational

Table 1: Effect of IPC training intervention on the students' knowledge scores

Variables	Before IPC intervention	After IPC intervention	Paired T Test P-value
Section A: General concept of Infection prevention and control [IPC]			
Mean score (Standard deviation)	4.07 (1.35)	6.8 (0.47)	<0.001
Median score (Interquartile range)	4 (2)	7 (0)	
Section B: Hand hygiene			
Mean score (Standard deviation)	9.70 (2.14)	13.71 (0.53)	<0.001
Median score (Interquartile range)	10 (3)	14 (0)	
Section C: Personal protective equipment [PPEs]			
Mean score (Standard deviation)	3.7 (J.13)	5.81 (0.44)	<0.001
Median score (Interquartile range)	4 (2)	6 (0)	
Section D:Respiratory hygiene and cough etiquette			
Mean score (Standard deviation)	3.55 (l.24)	5.76 (0.51)	<0.001
Median score (Interquartile range)	4 (1)	6 (0)	
Section E: Safe sharp and needle precautions			
Mean score (Standard deviation)	4.13 (0.88)	5.65 (0.55)	<0.001
Median score (Interquartile range)	4 (1)	6 (1)	
Section F: Knowledge about recommended vaccines for HCWs and biomedical waste management			
Mean score (Standard deviation)	1.9 (0.76)	2.8 (0.42)	<0.001
Median score (Interquartile range)	2 (1)	3 (0)	
Total			
Mean score (Standard deviation)	25.13 (4.51)	37.65 (l.37)	<0.001
Median score (Interquartile range)	20 (6)	38 (2)	

Paired T test was used data analysis.

Table 2: Students' IPC knowledge scores on sections of general concepts and hand hygiene - before and after IPC intervention

Variables	Knowledge score before IPC intervention	Knowledge score after IPC intervention	McNemar test P-value
	Correct responses: frequencies (n) and percentage (%)	Correct responses: frequencies (n) and percentage (%)	
Section A: General concept of Infection prevention and control [IPC].			
Cross-infections in the hospital occur only between patients ['FALSE'].	60 (48%)	120 (96%)	<0.001
The primary goal of standard precaution is to reduce infection ['TRUE'].	113 (90.4%)	123 (98.4%)	0.013
Standard precautions are recommended only whenever there is a risk of exposure to blood and body fluids ['FALSE'].	56 (44.8%)	120 (96%)	<0.001
Transmission-based precautions are also referred to as Standard precautions ['FALSE'].	34 (27.2%)	111 (88.8%)	<0.001
Early initiation of antibiotics is recommended for all patients diagnosed with pharyngitis ['FALSE'].	67 (53.6%)	119 (95.2%)	<0.001
Infections that become evident within a day of hospital admission ['FALSE'].	71 (56.8%)	119 (95.2%)	<0.001
Infections that become evident after 48 hours of hospital admission [Correct answer is 'TRUE'].	103 (82.4%)	122 (97.6%)	<0.001
Section B: Hand hygiene			
Hand hygiene is the single most effective method to prevent HAIs ['TRUE'].	89 (71.2%)	125 (100%)	<0.001
As per WHO recommendation, minimum duration for hand washing with soap and water [50-60 seconds].	57 (45.6%)	120 (96%)	<0.001
As per WHO recommendation, minimum duration for alcohol-based hand rub [20-30 seconds].	66 (52.8%)	121 (96.8%)	<0.001
One should take off all hand and wrist jewelry before hand washing ['TRUE'].	113 (90.4%)	125 (100%)	0.013
Arms should be bare below the elbow ['TRUE'].	96 (76.8%)	108 (86.4%)	0.088
Knowledge about correct sequence of hand washing procedure [ONE OPTION].	77 (61.6%)	122 (97.6%)	<0.001
Wearing glove without prior hand hygiene is permissible before an aseptic procedure ['FALSE'].	80 (64%)	122 (97.6%)	<0.001
Wearing artificial nails or nail products while hand washing is allowed ['FALSE'].	91 (72.8%)	123 (98.4%)	<0.001
Alcohol-based hand rub is preferred over hand washing with soap and water if hands are soiled ['FALSE'].	77 (61.6%)	121 (96.8%)	<0.001
Knowledge about 5 moments of hand hygiene.			
Before touching a patient.	120 (96%)	123 (98.4%)	0.375
Immediately before performing a clean or aseptic procedure.	110 (88%)	120 (96%)	0.031
After contact with body fluids regardless of whether gloves were used or not.	115 (92%)	122 (97.6%)	0.092
After touching a patient.	98 (78.4%)	122 (97.6%)	<0.001
After touching patient surroundings.	83 (66.4%)	119 (95.2%)	<0.001

McNemar test was used for data analysis.

training. Adequate IPC knowledge would help them to take necessary preventive measures during clinical training and later during their professional life to protect self and patients from HAIs. Ample evidence suggests that undergraduate health science students lack adequate IPC knowledge. However, we could not find studies related to the implementation of IPC training module in undergraduate medical curriculum and evaluation of its effectiveness in improving health science students' knowledge and practicing skills of IPC. To the best of our knowledge, it is a study first of its kind in Oman. In this study, we aimed to introduce and explore the effectiveness of IPC training in enhancing IPC knowledge and practicing skills among undergraduate clinical-year medical students at COMHS. We used a structured IPC training module comprising of the combination of didactic lectures, simulation, demonstration of skills such as hand hygiene, donning and doffing of PPE, wearing N95 mask, safe sharp and needle precautions, and others, followed by assessment of the participants' practicing skills. This modular IPC training was delivered by accredited infection control experts from Ministry of Health (MOH), Oman.

Table 3: Students' knowledge scores on sections PPE, respiratory and cough etiquette, safe needle precautions, and biomedical waste management and immunization - before and after IPC intervention

Variables	Knowledge score before IPC intervention	Knowledge score after IPC intervention	McNemar test P-value
	Correct responses: frequencies (n) and percentage (%)	Correct responses: frequencies (n) and percentage (%)	
Section C: Personal protective equipment [PPEs].			
There is no need to change the gloves between the patients' examination ['FALSE'].	99 (79.2%)	123 (98.4%)	<0.001
Oral cavity examination of a patient requires wearing of gloves ['TRUE'].	112 (89.6%)	120 (96%)	0.096
Wearing gloves while withdrawing venous blood is essential ['TRUE'].	101 (80.8%)	119 (95.2%)	0.001
Wearing face shield and mask is essential while dressing burns wound ['FALSE'].	71 (56.8%)	106 (84.8%)	<0.001
Correct knowledge about steps of donning PPEs [ONE CORRECT OPTION].	58 (46.4%)	122 (97.6%)	<0.001
Correct knowledge about steps of doffing of PPEs [ONE CORRECT OPTION].	17 (13.6%)	123 (98.4%)	<0.001
Section D: Respiratory hygiene and cough etiquette.			
Correct knowledge about difference between droplet and airborne infection [ONE OPTION].	55 (44%)	118 (94.4%)	<0.001
Cough/sneeze on your palms and clean the hands with alcohol rub ['FALSE'].	61 (48.8%)	121 (96.8%)	<0.001
Cough/sneeze over shoulder if a napkin is not available ['TRUE'].	74 (59.2%)	110 (88%)	<0.001
Keep 3 feet distance from others when coughing ['TRUE'].	89 (71.2%)	122 (97.6%)	<0.001
Wipe your hands on the inside of your white coat after you cough or sneeze ['FALSE'].	93 (74.4%)	119 (95.2%)	<0.001
N95 mask must be thrown away after each use.	76 (60.8%)	117 (93.6%)	<0.001
Section E: Safe sharp and needle precautions.			
Healthcare providers are at risk of acquiring HIV following needle stick injuries ['TRUE'].	122 (97.6%)	122 (97.6%)	1.000
HBV and HCV can be transmitted through needle stick injuries ['TRUE'].	115 (92%)	121 (96.8%)	0.180
After withdrawing blood from a patient, immediately recap the needle ['FALSE'].	54 (43.2%)	116 (92.8%)	<0.001
Injection needles should be bent or broken after use ['TRUE'].	51 (40.8%)	97 (77.6%)	<0.001
Used injection needles should be disposed of into leak proof container ['TRUE'].	82 (65.6%)	117 (93.6%)	<0.001
The appropriate immediate action after pricking finger by I.V. line needle is dressing wound and inform infection control supervisor ['TRUE'].	89 (71.2%)	121 (96.8%)	<0.001
Section F: Knowledge about recommended vaccines for HCWs and biomedical waste management			
For the prevention of hepatitis B, immunizations are recommended for all healthcare workers ['TRUE'].	114 (91.2%)	122 (97.6%)	0.057
Infective wastes such as soiled dressing material, human tissues etc. are disposed of into yellow coded container ['TRUE'].	56 (44.8%)	117 (93.6%)	<0.001
Surfaces contaminated with blood spillage in the hospital are disinfected by using sodium hypochlorite solution ['TRUE'].	48 (38.4%)	118 (94.4%)	<0.001

McNemar test was used for data analysis.

A recent study by Guevara *et al*. in Venezuela demonstrated mean IPC knowledge score among final year medical students as 18.1±1.62 (21). In contrast, our study participants had a better mean knowledge score (25.13±4.51) before training. Final year medical students have some basic overall knowledge about IPC but lack practicing skills. This could be because they had basic information of IPC during their training in preclinical year courses. Nearly half of our participants lacked knowledge on certain key aspects of IPC such as definition of HAI, standard duration of hand washing and steps of hand hygiene, donning and doffing of PPE, appropriate use of N95 mask, safe sharp and needle precautions, and biomedical waste management. Similar findings were reported by Nalunkuma *et al*. and Khubrani *et al*. (13, 22).

All our participants were aware of the importance of hand hygiene, but nearly 50% were unaware of standard time duration and steps of hand hygiene before training. Contrastingly, a

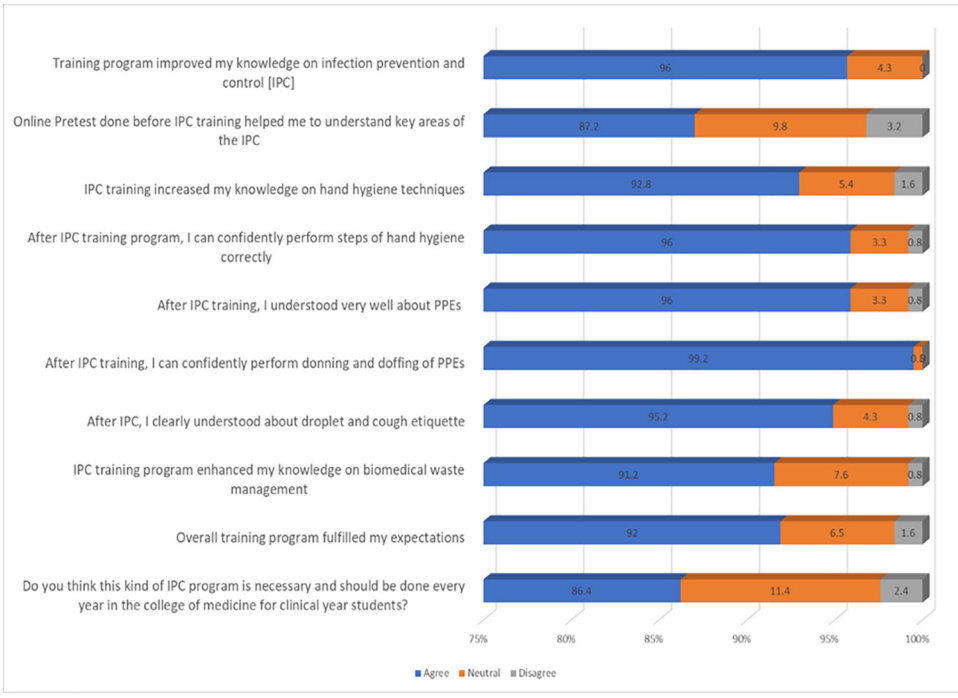

Figure 2: Students' perception regarding the effectiveness of IPC training session

previous study demonstrated correct knowledge about duration and steps of hand hygiene among 79% of the participants (22). Adherence to proper hand washing is the single most infection prevention strategy, and failure to have adequate knowledge on proper hand hygiene increases the risk of infection transmission between HCWs and patients (23). Therefore, enhancing knowledge and practicing skills of hand washing among HCWs including health science students plays a pivotal role in preventing infection transmission. In our study, mean knowledge score on hand hygiene after training (13.71±0.53) was significantly higher compared to that before training (9.7±2.14), suggesting that the majority (>95%) of our study participants gained adequate knowledge on hand hygiene including standard duration of hand washing and sequential steps of hand hygiene.

Adherence to standard precautions including wearing PPEs and respiratory and cough etiquette by HCWs depending on circumstances is another key element of IPC which aims to protect self and patients. In a study by John *et al*., only 53% of the participants reported to have received PPE training, and only 39% answered correctly for a question on donning and doffing sequence of PPE (24). Similarly, only 46.4% and 13.6% of our study participants knew correct sequence of donning and doffing of PPE, respectively, before training. Nearly 1 out of 2 were unaware of appropriate respiratory hygiene and cough etiquette with a mean knowledge score of 3.55±1.24. This suggests the importance of implementation of effective training module to train undergraduate medical students in appropriate use of PPE and proper respiratory hygiene and cough etiquette. In our study, basic IPC training was provided through the combination of didactic lectures, simulation, and practical demonstration of IPC techniques such as donning and doffing of PPE, hand hygiene, and wearing of N95 mask. Subsequently, students were allowed to practice skills of IPC, and their practicing skills were assessed by infection control experts. When students go through the situation where they must do what they need to learn, they become motivated and engaged in the learning process. Beyond that, learning by performing skills provides opportunities for learners to go through the sequential steps of the procedure, identify common mistakes, and refine strategies. Thus, mold them to reflect as better performers. Utilization of the learning tools that aim to teach the students practical skills make a link between theory and practice, thus contributing to blending knowledge and developing practical skills (25). Thus, structured learning strategy helped our participants to memorize key steps and demonstrate key skills of wearing PPE and N95 mask precisely.

Sections on safe sharp and needle precautions and biomedical waste (BMW) management indicated inadequate knowledge among our study participants with low correct responses to questions on "mutilating used needles before

disposal (40.8%), do not recap needle after use (43.2%), discard infectious wastes to yellow coded container (44.8%), and cleaning surfaces contaminated with blood spillages with sodium hypochlorite (38.4%)". Similar insufficient knowledge about needle precautions and BMW management among the participants was reported in studies by Khubrani *et al*. and Akkajit *et al.* (22, 26). Healthcare providers such as doctors, nurses, laboratory technicians, and house keepers are at high risk of sharp and accidental needle stick injuries. Previous studies have shown that the highest incidence of accidental needle stick injuries occurs during recapping of needles (27-29). These injuries are major cause of transmission of blood-borne infections such as HIV, HBV, and HCV (29). The risk of transmission of HBV, HCV, and HIV after percutaneous injuries is about 2-40%, 2.7-10%, and 0.3%, respectively (30). Among these, HBV is vaccine preventable, while there are no vaccines yet against HIV and HCV. Therefore, healthcare institutions must emphasize preventive measures to reduce the risk among HCWs (31). Education to enhance awareness among HCWs, training them on universal safety precautions such as safe disposal of infectious wastes in recommended color-coded containers, avoiding recapping of needles after withdrawal of blood, mutilating the needle after use, and safely discarding the used needles in leak-proof containers (32). Additionally, prompt reporting of accidental needle stick injuries and early initiation of recommended prophylaxis will play a key role in reducing the burden of these infections (33). Our study results confirm greater knowledge gain among participants in these aspects through the structured training session.

Our study also evaluated the students' perception on overall effectiveness of the training. All items in the questionnaire received excellent positive reception from the study participants. Didactic lectures alone are less appealing in encouraging the students to learn. Development of educational environment that motivates, supports critical thinking and problem-solving, and encourages the effective application of gained knowledge is highly essential. Our structured training included theory and practical skills, in addition to the assessment of learned content. This could have facilitated friendly and enjoyable learning environment in our participants. Nearly 90% of our participants recommended IPC training to be conducted every year and be initiated at the preclinical-year level.

Limitation

Our study had a few limitations. First, the study did not look for application of gained knowledge and technique in real practice by the participants. Therefore, it is recommended that further studies should be conducted to assess their real practice of gained IPC knowledge during their clinical training in hospitals. Second, the sample size was small involving single cohort of clinical-year undergraduate medical students. Hence, our study results cannot be generalized, and confirmation of our study results requires more multicentric studies.

Conclusion

A well-structured educational intervention IPC training module had a significant impact on knowledge gain and practicing skills of IPC among our participants. From our study results, it is recommended that IPC training module should be implemented in the undergraduate medical curriculum, preferably initiated at preclinical year level as repeated training sessions every year would help them to gain and retain adequate IPC knowledge and practicing skills. Moreover, IPC training must emphasize more practicing skills for clinical-year undergraduates.

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Authors' Contribution

M.B.S and V.N designed the study, then M.B.S wrote the search strategy and V.N performed the literature search. Data acquisition and Data analysis were done R.A and J.M, and then revived by A. J and M. S. All authors contributed to the discussion, read, and approved the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest: None Declared.

References

1. Szabó S, Feier B, Capatina D, Tertis M, Cristea C, Popa A. An Overview of Healthcare Associated Infections and Their Detection Methods Caused by Pathogen Bacteria in Romania and Europe. J Clin Med. 2022;11:3204.
2. Sannathimmappa MB, Nambiar V, Aravindakshan R. Antibiotic resistance pattern of Acinetobacter baumannii strains: Aretrospective study from Oman.

Saudi J Med Med Sci. 2021;9:254-60.
3. Bayleyegn B, Mehari A, Damtie D, Negash M. Knowledge, Attitude and Practise on Hospital-Acquired Infection Prevention and Associated Factors Among Healthcare Workers at University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. Infect Drug Resist. 2021;14:259-66.
4. North Dakota Department of Health [Internet]. Public Health: Healthcare Associated Infection. 2023 [Accessed 2 Jan 2023]. Available from: https://www.ndhealth.gov/disease/hai/Docs/HAIPreventionManual.pdf.
5. Overview of the IPC situation worldwide [Internet]. World Health Organization: highlights of achievements and gaps. 2022 [Last accessed on 7 March 2022]. Available from: https://apps.who.int/gb/MSPI/pdf_files/2022/03/Item1_07-03.pdf.
6. Al Humaid S, Al Mutair A, Al Alawi Z, Al-Sulaiman M, Ahmed GY, Rabaan AA, et al. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Antimicrob Resist Infect Control. 2021;10:86.
7. Haque M, Sartelli M, McKimm J, Bakar MA. Health care-associated infections–an overview. Infect Drug Resist. 2018;11:2321.
8. Chandra S, Chong D. Health Care–Associated Infections. In Critical Care; Oropello JM, Pastores SM, Kvetan V, Eds.; McGraw-Hill Education: New York, NY, USA; 2017.
9. Al-Tawfiq JA, Tambyah PA. Healthcare associated infections (HAI) perspectives. J Infect Public Health. 2014;7(4):339-44.
10. Ling ML, Apisarnthanarak A, Madriaga G. The Burden of Healthcare-Associated Infections in Southeast Asia: A Systematic Literature Review and Meta-analysis. Clin Infect Dis. 2015;60(11):1690-9.
11. Dejon R, Musinguzi G, Yu X, Buregyeya E, Musoke D, Wang JS, et al. Occupational health hazards among healthcare workers in Kampala, Uganda. J Environ Public Health. 2015;2015:913741.
12. Mohamad N, Pahrol MA, Shaharudin R, Yazin NKR, Osman Y, Toha HR, et al. Compliance to Infection Prevention and Control Practices Among Healthcare Workers During COVID-19 Pandemic in Malaysia. Front Public Health. 2022;10:878396.
13. Nalunkuma R, Nkalubo J, Abila DB. Knowledge on Infection Prevention and Control and associated factors among undergraduate health professional students at Makerere University College of Health Sciences, Uganda. PLoS ONE. 2021;16(8):e0255984.
14. Zenbaba D, Sahiledengle B, Takele A, Tekalegn Y, Yassin A, Tura B, et al. Compliance towards infection prevention measures among health professionals in public hospitals, southeast Ethiopia: a cross-sectional study with implications of COVID-19 prevention. Trop Med Health. 2021;49(1):30.
15. Ojulong J, Mitonga KH, Iipinge SN. Knowledge and attitudes of infection prevention and control among health sciences students at University of Namibia. Afr Health Sci. 2013;13(4):1071-8.
16. Oman National Healthcare Accreditation System [Internet]. 2022 [Last accessed November 4, 2022]. Available from: https://www.moh.gov.om/en/web/directorate-quality-assurance-center/national-accreditation-standards.
17. Abalkhail A, Al Imam MH, Elmosaad YM, Jaber MF, Hosis KA, Alhumaydhi FA, et al. Knowledge, Attitude and Practise of Standard Infection Control Precautions among Health-Care Workers in a University Hospital in Qassim, Saudi Arabia: A Cross-Sectional Survey. Int J Environ Res Public Health. 2021;18(22):11831.
18. Yazie TD, Sharew GB, Abebe W. Knowledge, attitude, and practise of healthcare professionals regarding infection prevention at Gondar University referral hospital, northwest Ethiopia: a cross-sectional study. BMC Res Notes. 2019;12(1):563.
19. Jemal K, Gashaw K, Kinati T, Bedada W, Getahun B. Clean and Safe Healthcare Environment: Knowledge, Attitude, and Practise of Infection Prevention and Control among Health Workforce at North Showa Zone Oromiya Region. J Environ Public Health. 2020;2020:6021870.
20. Loftus MJ, Curtis SJ, Naidu R, Cheng AC, Jenney AWJ, Mitchell BG, et al. Prevalence of healthcare-associated infections and antimicrobial use among inpatients in a tertiary hospital in Fiji: a point prevalence survey. Antimicrob Resist Infect Control. 2020;9(1):146.
21. Guevara A, González O, Salazar P, Tedesco-Maiullari R, Gascón C. Knowledge about healthcare-associated infections in medical, bioanalysis and nursing students from a Venezuelan university. Rev Fac Med. 2020;68(1):59-65.
22. Khubrani A, Albesher M, Alkahtani A, Alamri F, Alshamrani M, Masuadi E. Knowledge and information sources on standard precautions and infection control of health sciences students at King Saud bin Abdulaziz University for Health Sciences, Saudi Arabia, Riyadh. J Infect Public Health. 2018;11(4):546-9.
23. Ahmed J, Malik F, Memon ZA, Bin Arif T, Ali A, Nasim S, et al. Compliance and Knowledge of Healthcare Workers Regarding Hand Hygiene and Use of Disinfectants: A Study Based in Karachi. Cureus. 2020;12(2):e7036.
24. John A, Tomas ME, Hari A, Wilson BM, Donskey CJ. Do medical students receive training in correct use of personal protective equipment? Med Educ Online. 2017;22(1):1264125.
25. Joint Commission on Accreditation of Healthcare Organization [Internet]. National Patient Safety Goals. 2015 [Last assessed 20 Jan 2015]. Available from: http://www.jointcommission.org/PatientSafety/NationalPatientSafetyGoals.
26. Akkajit P, Romin H, Assawadithalerd M. Assessment of Knowledge, Attitude, and Practise in respect of Medical Waste Management among Healthcare Workers in Clinics. J Environ Public Health. 2020;2020:8745472.
27. Jahan S. Epidemiology of needlestick injuries among health care workers in a secondary care hospital in Saudi Arabia. Ann Saudi Med. 2005;25(3):233-8.
28. Memish ZA, Assiri AM, Eldalatony MM, Hathout HM. Benchmarking of percutaneous injuries at the Ministry of Health hospitals of Saudi Arabia in comparison with the United States hospitals participating in Exposure Prevention Information Network (EPINet™). Int J Occup Environ Med. 2015;6:26–33.
29. Sannathimmappa MB, Nambiar V, Arvindakshan

R. Hepatitis B: Knowledge and awareness among preclinical year medical students. Avicenna J Med. 2019;9:43-7.
30. Wilburn SQ, Eijkemans G. Preventing needlestick injuries among healthcare workers: a WHO-ICN collaboration. Int J Occup Environ Health.2004;10:451–6.
31. Action Plan for the Prevention, Care & Treatment of Viral Hepatitis [Internet]. 2014 [Updated 2014-2016]. Available from: https://www.hhs.gov/sites/default/files/viral-hepatitis-action-plan.pdf.
32. Tarigan L, Cifuentes M, Quinn M, Kriebel D. Prevention of needle-stick injuries in healthcare facilities: a meta-analysis. Infect Control Hosp Epidemiol. 2015;36:823–9.
33. Benn P, Fisher M, Kulasegaram R. UK guideline for the use of post-exposure prophylaxis for HIV following sexual exposure, 2011. Int J Std AIDS. 2011;22:695–708.