

## RESEARCH ARTICLE

# In-person training on COVID-19 case management and infection prevention and control: Evaluation of healthcare professionals in Bangladesh

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## Abstract

### Background

As COVID-19 was declared a global pandemic, the major focus of healthcare organizations shifted towards preparing healthcare systems to handle the inevitable COVID-19 burden at different phases and levels. A series of in-person training programs were operated in collaboration with government and partner organizations for the healthcare workers (HCW) of Bangladesh. This study aimed to assess the knowledge of HCWs regarding SARS-CoV-2 infection, their case management, infection prevention and control to fight against the ongoing pandemic.

### Methods

As a part of the National Preparedness and Response Plan for COVID-19 in Bangladesh, the training program was conducted at four district-level hospitals and one specialized hospital in Bangladesh from July 1, 2020 to June 30, 2021. A total of 755 HCWs participated in the training sessions. Among them, 357 (47%) were enrolled for the evaluation upon completion of the data, collected from one district hospital (Feni) and one specialized hospital (National Institute of Mental Health).

### Results

The mean percentage of pre-test and post-test scores of all the participants were found to be 57% (95% CI 8.34–8.91;  $p < 0.01$ ) and 65% (95% CI 9.56–10.15;  $p < 0.001$ ) respectively. The difference of score (mean) between the groups was significant ( $p < 0.001$ ). After

have the provision to disclose any kind of information. Thus, our policy is not to make available the data set in the manuscript, the supplemental files, or a public repository. However, data related to this manuscript are available upon request and researchers who meet the criteria for access to confidential data may contact Ms. Armana Ahmed ([aahmed@icddr.org](mailto:aahmed@icddr.org)) at the research administration of icddr,b (<http://www.icddr.org>).

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categorizing participants' knowledge levels as poor, average and fair, doctors' group has shown to have significant enhancement from level of average to fair compared to that of the nurses. Factors associated with knowledge augmentation of doctors were working in primary health care centers (aOR: 4.22; 95% CI: 1.80, 9.88), job experience less than 5 years (aOR: 4.10; 95% CI: 1.01, 16.63) and experience in caring of family member with COVID-19 morbidity (aOR: 2.06; 95% CI: 1.03, 4.10), after adjusting for relevant covariates such as age, sex and prior COVID-19 illness.

## Conclusion

Considering the series of waves of COVID-19 pandemic with newer variants, the present paper underscores the importance of implementing the structured in-person training program on case management, infection prevention and control for the HCWs that may help for successful readiness prior to future pandemics that may further help to minimize the pandemic related fatal consequences.

## Background

The novel Coronavirus emerged in Wuhan, China in late December 2019, and Bangladesh had reported its first case on 8th March 2020 [1, 2]. Researchers identified the basic reproductive number of the virus, which is higher than many deadly infectious diseases, that eventually overwhelmed healthcare facilities in developing as well as developed nations [3]. The health care system in Bangladesh is typical of any developing country setting and was not fully capable of handling the raging Coronavirus pandemic [4]. However, as the first responders, healthcare workers (HCWs) immediately responded with team efforts in delivering health care and essential services to save lives [5]. In the battle against SARS-CoV-2, Bangladesh has lost nearly 9,400 healthcare workers including 3,106 doctors, 2,281 nurses and 4,015 other individuals related to health service delivery [6]. The sudden spread of the pandemic with fear of contracting the deadly disease abruptly halted all types of in-person skilled training when it was a dire need [2].

In a developing country like Bangladesh, the healthcare workforce is already burdened with routine health care as well as with public health threat issues, including undernutrition, non-communicable diseases, etc., which might impede adopting preventive measures and facilitating care of COVID-19 [7]. A recent study estimated the high workload of Bangladeshi physicians and nurses with a coverage of 3.04 and 1.07 per 10,000 individuals respectively [8]. Due to heavy workload, HCWs often could not practice and follow the critical preventive health measures such as frequent hand hygiene [9]. Moreover, the case-fatality-rate from COVID-19 among the doctors is highest in Bangladesh compared to other affected countries [10]. Considering the intensifying health risk, the Government of Bangladesh conducted a National Preparedness and Response Plan for COVID-19, jointly with international development partners, which indicated the need for hands-on training for doctors, nurses and clinical care support staff [11]. This ranges from prevention of the infection that the health system staff members will be allowed to practice as preventative measures to be consistently followed later by the HCWs to protect themselves and facilitate infection control, and treatment of COVID-19 patients [12].

Despite developing various guidelines for the infection prevention and control procedures and case management of COVID-19 by the Government of Bangladesh, the pandemic

triggered the shut-down of all in-person educational activities. Consequently this placed the unprepared health workforce at utmost risk and simultaneously made them susceptible to spread the transmission [13]. During the COVID-19 pandemic, scientific sessions, conferences and training events were switched to a virtual platform. Although considering a better forum for networking, information exchange and group-based peer learning, we preferred conventional in-person trainings. Under these circumstances, an in-person training program was conducted emphasizing on epidemiology, microbiology, prevention and control and treatment of COVID-19 for the HCWs of different districts of Bangladesh from 1<sup>st</sup> July 2020 to 30<sup>th</sup> June 2021 with support from Global Affairs Canada (GAC). Such endeavor was carried out by a dedicated team comprising of physicians, nurses and infection prevention and control specialist from icddr,b.

Literature review indicated that in-person training on an acute emergency disorder encouraged team building in healthcare delivery, leadership and thus improved the performance of caregivers [14]. The objective of our study was to explore the effectiveness of the training program by comparing the pre-test and post-test scores of the participants and formulate better strategies for designing more in-person training in future during any large-scale outbreak in Bangladesh.

## Method

### Study site

The training was conducted in four district and one specialized hospitals (including 21 health facilities). The district hospitals have secondary level health facility (location in Chandpur, Narail, Magura, and Feni) whereas the specialized hospital named National Institute of Mental Health (NIMH) has tertiary level health facility. As per the National Health Service (NHS), medical care is provided in two main ways: primary care (by general practitioners and community services) and secondary care (hospitals and specialists). Difference between primary and secondary healthcare: day-to-day healthcare in every local area is considered as primary health care, whereas secondary healthcare is the specialist treatment and support provided by doctors and other health professionals for patients who are referred to them for specific expert care, most often provided in hospitals.

These facilities were selected as they were directly involved in providing optimal care for COVID-19 cases or prepared to hospitalize and manage in case of exceeding the number of cases of COVID-19. Both the health facilities are from urban and sub-urban locality.

### Study participants

Participants were selected by the hospital authority considering their engagement in clinical work and overseeing roles in the team. Moreover, from each hospital, one focal person was selected as an Infection Prevention and Control (IPC) lead who would continue conducting the similar in-house sessions for other staff members after the completion of their training. Among the total 755 participants, 294 were physicians, 335 were nurses and 126 were clinical support staff. If we divide them district wise, the distribution seems like- in Chandpur (n = 79), Narail (n = 141), Magura (n = 97), Feni (n = 264) and, (n = 174) in Dhaka.

We have purposively selected 357 members of the health workforce for the current study, where we aimed to explore the improvement of knowledge by the training program by evaluating their performance in pre-test and post-test assessment sessions.

### Inclusion criteria

Participants from NIMH (specialized hospital) and one district hospital (Feni) were selected for the comparison of this pre and post study at the targeted level of scores.

### Exclusion criteria

We excluded participants from the analysis if either of the pre-test or the post-test performance was incomplete by the respective member of the health workforce.

### Study design

This was a cross-sectional study. The study participants of this analysis were the individuals who received training in a COVID-19 training program that aimed at the capacity development of healthcare workers in taking care of COVID-19 cases in Bangladesh.

### Instruments

A self-directed, semi-structured questionnaire ([S1 Questionnaire](#)) was developed by the investigators of the study where identity of the participants was masked. The questionnaire was in English and attached as a [S1 Questionnaire](#). We have used the identical 15 questions for both pre-test and post-test. Thus four domains (epidemiology, clinical manifestation, case management, and infection prevention and control) had 3, 2, 2 and 8 questions respectively. We categorized the knowledge as poor, average and fair if the participant scored 0–5, 6–10 and 11–15 respectively. The questionnaire was validated in-house among trainee physicians of Dhaka Hospital of icddr, b as a piloting approach. In addition, there were questions about the respondent's age, sex, educational background, workplace, current working position with joining date, COVID-19 morbidity experience (either self-infection or the infection of a family member) and their feedback regarding their liking and disliking of the training. All the course materials were provided to the participants in the form of handout of presentation.

### Description of training

As a part of the National Preparedness and Response Plan for COVID-19 in Bangladesh, a rapid facility assessment for national health facility readiness and preparedness for COVID-19 was commissioned. The Directorate General of Health Services (DGHS) initiated the process with support from development partners, UN agencies, and other national and international agencies. USAID's Medicine, Technologies and Pharmaceuticals Services (MTaPS) Program, implemented in Bangladesh by Management Sciences for Health (MSH), supported DGHS with the assessment. It was a two-day session for doctors, one day session for nurses and other support staff members.

For doctors and nurses, different sets of training curriculum and training materials were used as appropriate considering the compatible topics and modules focusing on their levels of understanding. After each module, a comforting refreshment break was arranged in every training session. A flexible approach was adopted for delivering the training materials, that included theoretical sessions, practical demonstrations and interactive discussions.

### Curriculum of the training

The goal of the training was to empower the healthcare workforce to fight COVID-19 by achieving confident, skills and knowledge and simultaneously implementing evidence-based strategies in healthcare settings. Thus, the training modules were designed to document knowledge, attitude and practice of the participants related to COVID-19 pandemic.

The IPC modules included the importance of triage, principles of IPC, standard precautions and transmission-based precautions, waste management and environmental decontamination and vaccine development. The case management modules included: the epidemiology of SARS-CoV-2; clinical manifestations of COVID-19; diagnostic strategy and treatment of COVID-19 cases.

### Sample size

We have collected information from 357 participants (214 from district level hospitals and 143 from a tertiary level/specialized hospital) after excluding 12 participants (8 and 4, respectively) because of their incomplete response in either of the two sessions.

Assuming 20% of the participants might lack in improvement of knowledge and skill after the training sessions, the estimated sample size with 80% power at a 95% confidence limit and 5% precision was 246, which is convenient for the present evaluation. The evaluation was purposively selected after meeting the exclusion criteria based on unintended to comply with providing personal and job related information

### Statistical analysis

The data entry, coding, and editing were performed using SPSS version 20 (Chicago, IL, USA). The SPSS file was then imported into Stata 15 software and all statistical analyses were performed using Stata (Stata Statistical Software: Release 15, College Station, Texas 77,845, USA: Stata Corp LLC). Descriptive statistics included frequencies, percentages, mean, standard deviation which were used to summarize data. Statistical plots such as cluster diagram, and pie charts were reviewed for data visualization. To estimate the inferential statistics, odds ratio with 95% confidence interval was used. We compared the baseline characteristics of the training participants by using chi-square tests, and t-test was used to see the significance of mean difference between pre-test and post-test scores. Logistic regression analysis revealed the more distinctive association between participants' characteristics and pre-test and post-test scores.

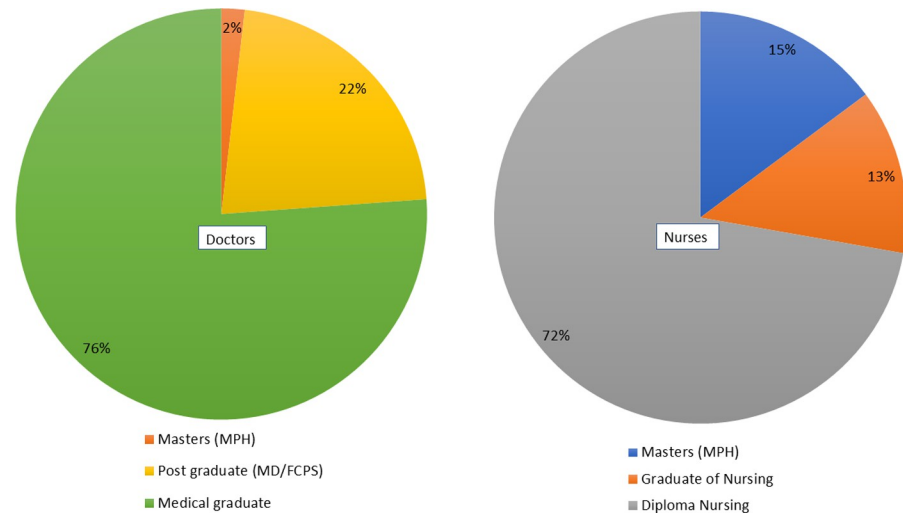
### Ethical approval

Ethical approval for the training activity was obtained from the Research Review Committee and Ethical Review Committee of the International Centre for Diarrhoeal Diseases Research, Bangladesh (icddr,b)(ACT-01112) on 25<sup>th</sup> June 2020. All participants provided voluntary written consent and actively participated in the pre-test and post-test sessions.

### Results

From 1<sup>st</sup> July 2020 to 30<sup>th</sup> June 2021, a total of 755 health care providers participated in the training sessions. Among them, 357 (47%) participants (doctors and nurses) were assessed by the pre-test and post-test. Out of the 357, 208 (58.26%) were nurses with a diploma in Nursing (72%). Among the physicians, nearly one-fourth had specialization either in medicine or surgery (Fig 1).

Table 1 summarizes the characteristics of the study population. The mean age of the population was  $(32.82 \pm 4.99)$  years for doctors and  $(35.46 \pm 8.31)$  years for nurses. About 72% of the total respondents were female. More than half (59.94%) of the participants were from primary and secondary level healthcare facilities. Approximately 80% of doctors had an average working experience of less than five years, whereas one-third of the nurses had a working experience of more than ten years (Table 1). The doctors suffered from COVID-19 more often than the nurses as well as they had witnessed sufferings of family members more frequently than the nurses.



**Fig 1. Academic contexts of the participating doctors and nurses.**

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Table 2 shows the participants' overall pre-test and post-test scores according to their current working location. Participants working in the primary healthcare facility achieved higher scores in pre-test and post-test assessments than the other participants from secondary or tertiary level facilities. Nurses working in the primary healthcare facilities achieved higher post-test scores than the other nurses. However, doctors working in all three settings achieved similar post-test scores of more than 80%.

The knowledge levels regarding epidemiology, clinical manifestation, case management and infection prevention and control are presented in Table 3. The results observed that all the participants achieved more than 50% pre-test scores and significantly higher post-test scores in all four domains.

We have presented the knowledge of the participants into three categories. Table 4 shows the distribution of participants' knowledge level according to the characteristics of the participants before and after conducting the training. There was an overall significant improvement

**Table 1. Demographic and occupational characteristics of the participants.**

Variables	Overall (N = 357)	Doctors (n = 149) (%)	Nurses (n = 208) (%)	p-value
Age, mean±SD	-	32.82±4.99	35.46±8.31	0.005
Female sex	256	64 (42.95)	192 (92.31)	<0.001
Training site, n (%)	357			
Specialized hospital	143	53 (35.57)	90 (43.27)	0.143
District hospital	214	96 (64.43)	118 (56.73)	
Current working station, n (%)	357			
Primary health care facility (sub-district facility)	118	61 (40.94)	57 (27.40)	0.027
Secondary health care facility (district facility)	96	35 (23.49)	61 (29.33)	
Years of experience, n (%)	217			
<5 years		91 (81.25)	59 (56.19)	<0.001
5–10 years		16 (14.29)	12 (11.43)	
>10 years		5 (4.46)	34 (32.38)	
COVID-19 infection, n (%)	67	42 (37.84)	25 (23.81)	0.026
COVID-19 exposure from the family, n (%)	55	50 (45.05)	5 (22.73)	0.052

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Table 2. Current working station wise comparison of pre-test and post-test scores of the participants.

		Pre-test score (n = 357), Mean %	Post-test score (n = 357), Mean %	p value
Primary Healthcare Centre	Overall	63.39	71.58	<0.001
	Doctors	75.30	81.64	<0.001
	Nurses	50.64	60.82	<0.001
Secondary Healthcare Centre	Overall	56.18	65.21	<0.001
	Doctors	72.95	81.33	<0.001
	Nurses	46.56	55.96	<0.001
Tertiary Healthcare Centre	Overall	53.61	61.17	<0.001
	Doctors	68.05	80.38	<0.001
	Nurses	45.11	49.85	<0.001

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in the scores from an average level to a fair level. A significant improvement of scores from an average level to acceptable fair level was observed among participants of all categories except those who experienced COVID-19 morbidity.

Fig 2 shows the categorical evaluation of the scores of both doctors and nurses. There is an obvious improvement of knowledge score for the doctors compared to the nurses. There was a significant decrease in the proportion of average level in post-test (11%) than pre-test (40%) ( $p < 0.001$ ) and increased significantly in the proportion of fair level in post-test (87%) than pre-test (59%). On the other hand, there was no remarkable change in the scores of the nurses.

Results of unadjusted (uOR) and adjusted odds ratios (aOR) computed by logistic regression are shown in Table 5. The observed improvement is reflected as an increase in scores in case of doctors (aOR: 16.27; 95% CI: 5.68, 46.56). Participants currently working in a secondary healthcare facility (aOR: 2.88; 95% CI: 1.07, 7.72) and primary healthcare facility (aOR: 4.22; 95% CI: 1.80, 9.88), having working experience of 5–10 years (aOR: 4.72; 95% CI: 1.15, 19.39) or less than 5 years (aOR: 4.10; 95% CI: 1.01, 16.63) were more likely to achieve a better post-test score. Participants who experienced in caring of a family member with COVID-19 (aOR: 2.06; 95% CI: 1.03, 4.10) achieved significantly higher post-test scores (Table 5).

## Discussion

The COVID-19 pandemic has revealed deep inequities in the global healthsystem to mitigate health emergency prevention response. A number of independent reviews have identified numerous gaps and weaknesses in the health system preparedness for any pandemic, more-over the condition is worse in developing country. The present study underpins one of the very few published studies assessing knowledge and preventive behaviors of healthcare workforce towards COVID-19 management in Bangladesh. Government reports have identified high COVID-19 burden districts of Bangladesh, where in-person training impacted meaningfully in managing COVID-19 cases [15]. The major strength of our research paper is the larger sample size and district-wise distribution of working-location of participants, which provided a

Table 3. Comparison of pre-test and post-test scores of all the participants on the basis of four domains of different questions.

Domain Name	Pre-test score (n = 357), Mean %	Post-test score (n = 357), Mean %	p value
Epidemiology	72.36	82.17	<0.001
Clinical manifestations	52.24	62.04	<0.001
Case management	56.44	67.65	<0.001
Infection prevention and control	53.61	59.98	<0.001

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Table 4. Comparative characteristics of the participants between different results level of pre-test and post-test.

	Results	Pre-test (n = 357)	Post-test (n = 357)	p-value
		Frequency (%)	Frequency (%)	
Overall	Poor level (0–5)	41(11.48)	27(7.56)	0.074
	Average level (6–10)	210(58.82)	173(48.46)	<b>0.005</b>
	Fair level (11–15)	106(29.69)	157(43.98)	<b>0.000</b>
Age (<35)	Poor (0–5)	11(7.80)	7(4.96)	0.330
	Average (6–10)	70(49.65)	58(41.13)	0.151
	Fair (11–15)	60(42.55)	76(53.90)	0.057
Age (≥35)	Poor (0–5)	16(21.62)	9(12.16)	0.125
	Average (6–10)	43(58.11)	36(48.65)	0.249
	Fair (11–15)	15(20.27)	29(39.19)	<b>0.012</b>
Male	Poor (0–5)	3(2.97)	3(2.97)	1.000
	Average (6–10)	43(42.57)	22(21.78)	<b>0.002</b>
	Fair (11–15)	55(54.46)	76(75.25)	<b>0.002</b>
Female	Poor (0–5)	38(14.84)	24(9.38)	0.058
	Average (6–10)	167(65.23)	151(58.98)	0.145
	Fair (11–15)	51(19.92)	81(31.64)	<b>0.002</b>
Tertiary Healthcare Center	Poor (0–5)	22 (15.38)	15(10.49)	0.217
	Average (6–10)	91(63.64)	81(56.64)	0.227
	Fair (11–15)	30(20.98)	47(32.87)	<b>0.023</b>
Primary and Secondary Healthcare Center	Poor (0–5)	19(8.88)	12(5.61)	0.192
	Average (6–10)	119(55.61)	92(42.99)	<b>0.009</b>
	Fair (11–15)	76(35.51)	110(51.40)	<b>0.001</b>
COVID-19 infection	Poor (0–5)	5(7.46)	4(5.97)	0.730
	Average (6–10)	33(49.25)	25(37.31)	0.163
	Fair (11–15)	29(43.28)	38(56.72)	0.120
Not-infected with COVID-19	Poor (0–5)	22(14.77)	13(8.72)	0.105
	Average (6–10)	81(54.36)	69(46.31)	0.164
	Fair (11–15)	46(30.87)	67(44.97)	<b>0.012</b>
COVID-19 exposure from the family	Poor (0–5)	1(1.82)	2(3.64)	0.558
	Average (6–10)	21(38.18)	6(10.91)	<b>0.001</b>
	Fair (11–15)	33(60.00)	47(85.45)	<b>0.003</b>
Not exposed to COVID-19 from family	Poor (0–5)	4(5.13)	1(1.28)	0.173
	Average (6–10)	37(47.44)	23(29.49)	<b>0.021</b>
	Fair (11–15)	37(47.44)	54(69.23)	<b>0.006</b>

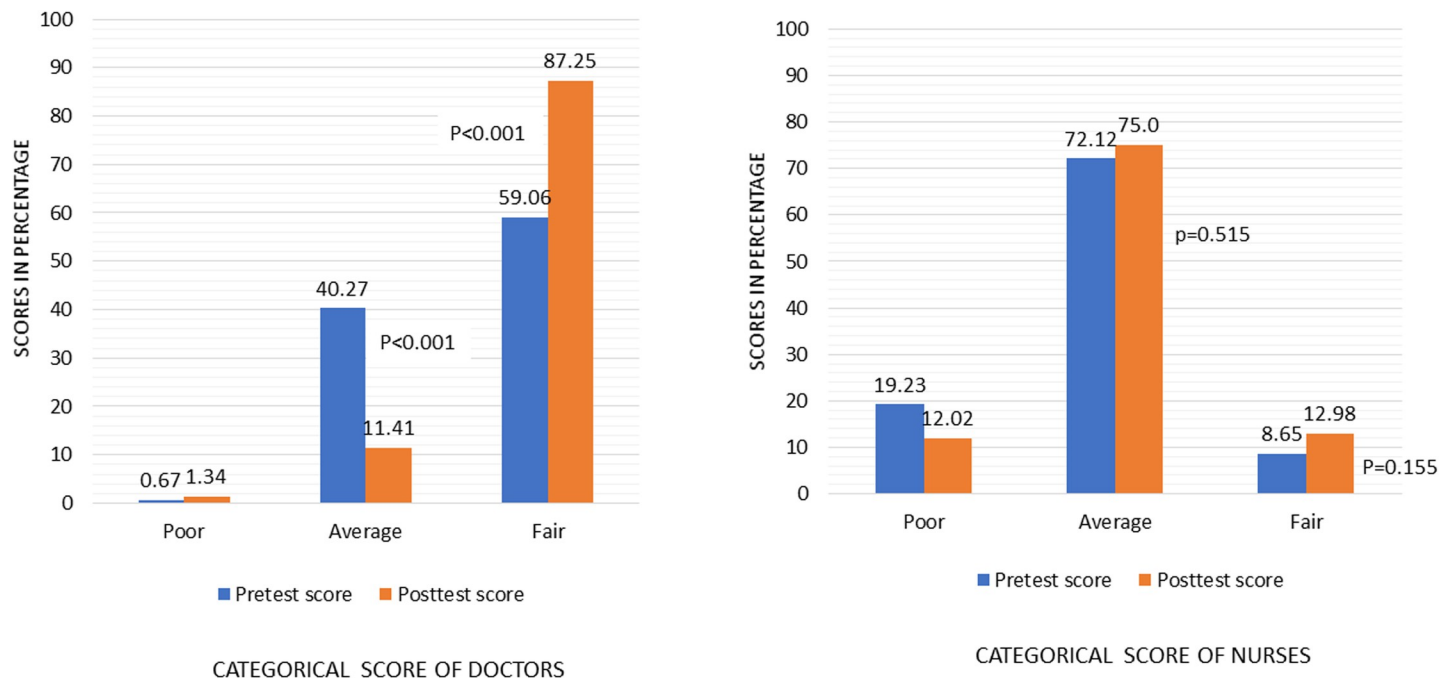
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better insight of the scenario towards COVID-19 care in Bangladesh. The aim of our study was to quantify the knowledge gained through the COVID-19 on-site training in Bangladesh.

Our study observed female-dominated cluster of participants. However, both males and females performed equally in assessment tests. While searching for the gender-wise acquaintances of knowledge on COVID-19, reports showed that male participants achieved better knowledge than their female counterpart [16, 17], which differed in our research.

Due to easier accessibility of information in urban areas, previous studies have reported a higher level of knowledge among individuals living in urban areas [16, 18], although our study has shown contrasting findings. Participants assigned to rural healthcare facilities like primary healthcare facilities (sub-district health facilities) and, secondary health care facilities (district health facilities) have demonstrated better performance in training assessment. This can be





**Fig 2. Pretest-posttest score level of doctors and nurses.**

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explained by the knowledge saturation of the urban participants through easier accessibility of educational modules on COVID-19 [19].

Our study explored the association of length of working experience with better knowledge gain among the participants. The study revealed the fact that knowledge gain was inversely related to the year of job experience. From the Bangladesh Government civil service perspective, it is prudent to mention that those who have fewer years of job experience belong to younger age group. It is prudent to mention that young people are well-motivated in acquiring and synthesising of new knowledge than the older people. Moreover, there were some restriction of in-person involvement of patient care in the age group of over forty. As younger health care workers involved actively in patient care from the beginning of pandemic, they were more engaged in the training, hence acquired better knowledge compared to their older peers. In other word, it is obvious from previous literatures that young people are better achievers of learning new knowledge and skills [20] compared to the aged people [21]. Moreover, participants exposed to a COVID-19 sick family member performed better in the assessment tests. Previous studies also reported that healthcare workers were in constant mental worries for potential transmission of the virus to their family members [22] and therefore, would be better experienced in COVID-19 patient care if having practical experience in caring for their sick family members [23].

Nurses and clinicians are two major pillars of any healthcare facility and are instrumental in the case management of COVID-19 pandemic. In particular, it is necessary to assess the knowledge gained in a conventional way of in-person training, which is followed by an impact assessment of the training, to ascertain the future needs of the training program during a pandemic situation. The study's outcome could be helpful while developing an effective and productive infrastructure.

The study is not devoid of limitations. Firstly, we could not include all the participants who received training that could have resulted in difference in the evaluation. In addition, we

Table 5. Associated factors of the participants with pretest and posttest scores.

Indicators	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
<b>Age</b>				
≥35	Reference		Reference	
<35	2.20 (1.44, 3.36)	<0.001	1.16 (0.52, 2.59)	0.711
<b>Sex</b>				
Female	Reference		Reference	
Male	5.31 (3.74, 7.54)	<0.001	1.38 (0.70, 2.72)	0.348
<b>Position</b>				
Nurses	Reference		Reference	
Doctors	22.47 (15.03, 33.57)	<0.001	16.27 (5.68, 46.56)	<0.001
<b>Current working station</b>				
Tertiary Healthcare Center	Reference		Reference	
Secondary Healthcare Center	1.49 (1.00, 2.21)	0.048	2.88 (1.07, 7.72)	0.036
Primary Healthcare Center	2.71 (1.88, 3.91)	<0.001	4.22 (1.80, 9.88)	0.001
<b>Years of experience</b>				
>10 years	Reference		Reference	
5–10 years	10.14 (3.98, 25.88)	<0.001	4.72 (1.15, 19.39)	0.032
<5 years	9.87 (4.40, 22.17)	<0.001	4.10 (1.01, 16.63)	0.049
<b>COVID-19 infection</b>				
No	Reference		Reference	
Yes	1.64 (1.08, 2.47)	0.019	1.07 (0.56, 2.07)	0.831
<b>COVID-19 exposure from the family</b>				
No	Reference		Reference	
Yes	1.90 (1.12, 3.23)	0.016	2.06 (1.03, 4.10)	0.041

After adjusting for relevant covariates, there was no significant association between scores and the participants by age, sex, and who infected by COVID-19.

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assessed the effectiveness of the on-site training program by performing pre-test and post-test that can measure only short-term memory. On the other hand, the real-time practice of IPC and COVID-19 management was not evaluated through observations for a sufficient time period in case of this training. Lastly, we were not able to adjust for the changes in trainers for different modules of the training.

In conclusion, the results of our training clearly indicate that the HCWs were benefitted by attending structured training on COVID-19 case management, infection prevention and control. To nurture their expertise more training program need to be developed and implemented on both preventive and curative care of COVID-19 patients in different hospitals that may further help for rapid preparedness and optimal implementation planning for any pandemic similar to COVID-19.

## Supporting information

### S1 Questionnaire.

(PDF)

### S1 Table. Change of knowledge between pre-test and post-test among participants.

(DOCX)

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## References

1. Yasmin R, Parveen R, Al Azad N, Deb SR, Paul N, Haque MM, et al. Corona virus infection among healthcare workers in a COVID dedicated tertiary care hospital in Dhaka, Bangladesh. *Journal of Bangladesh College of Physicians and Surgeons*. 2020:43–9.
2. Razu SR, Yasmin T, Arif TB, Islam M, Islam SMS, Gesesew HA, et al. Challenges faced by healthcare professionals during the COVID-19 pandemic: a qualitative inquiry from Bangladesh. *Frontiers in public health*. 2021:1024. <https://doi.org/10.3389/fpubh.2021.647315> PMID: 34447734
3. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *New England journal of medicine*. 2020. <https://doi.org/10.1056/NEJMoa2001316> PMID: 31995857
4. Organization WH. Surveillance protocol for SARS-CoV-2 infection among health workers: 28 May 2020. World Health Organization, 2020.
5. Rana B, HEI S, COVID W. WHO Bangladesh COVID-19 Situation Report #06. Dhaka: WHO; 2020.

6. Tribune D. Over 180 doctors killed due to coronavirus in Bangladesh. 2020.
7. Elhadi M, Mshergahi A, Alkeelani M, Zorgani A, Zaid A, Alsuyhili A, et al. Assessment of healthcare workers' levels of preparedness and awareness regarding COVID-19 infection in low-resource settings. *The American journal of tropical medicine and hygiene*. 2020; 103(2):828. <https://doi.org/10.4269/ajtmh.20-0330> PMID: 32563273
8. Al-Zaman MS. Healthcare crisis in Bangladesh during the COVID-19 pandemic. *The American journal of tropical medicine and hygiene*. 2020; 103(4):1357. <https://doi.org/10.4269/ajtmh.20-0826> PMID: 32828138
9. icddr b. Bangladesh National Hygiene Baseline Survey. Dhaka; 2014.
10. Hussain M, Begum T, Batul SA, Tui NN, Islam MN, Hussain B. Healthcare workers during the COVID-19 pandemic: Experiences of doctors and nurses in Bangladesh. *The International Journal of Health Planning and Management*. 2021. <https://doi.org/10.1002/hpm.3154> PMID: 33819348
11. DGHS. Bangladesh Preparedness and Response Plan for COVID-19. In: DGHS, editor. Dhaka: Ministry of Health & Family Welfare; 2020.
12. Yeasmin S, Banik R, Hossain S, Hossain MN, Mahumud R, Salma N, et al. Impact of COVID-19 pandemic on the mental health of children in Bangladesh: A cross-sectional study. *Children and youth services review*. 2020; 117:105277. <https://doi.org/10.1016/j.childyouth.2020.105277> PMID: 32834275
13. Division DC. National Guidelines on Clinical Management of Coronavirus Disease 2019 (Covid-19). In: DGHS, editor. 30 March 2020 ed2020.
14. Organization WH. Responding to COVID-19: Real-time training for the coronavirus disease outbreak. Available online (Accessed on 1 April 2020)[Link]. 2020.
15. Hosen I, Pakpour AH, Sakib N, Hussain N, Al Mamun F, Mamun MA. Knowledge and preventive behaviors regarding COVID-19 in Bangladesh: A nationwide distribution. *PLoS One*. 2021; 16(5):e0251151. <https://doi.org/10.1371/journal.pone.0251151> PMID: 33939763
16. Hossain MA, Jahid MIK, Hossain KMA, Walton LM, Uddin Z, Haque MO, et al. Knowledge, attitudes, and fear of COVID-19 during the Rapid Rise Period in Bangladesh. *PloS one*. 2020; 15(9):e0239646. <https://doi.org/10.1371/journal.pone.0239646> PMID: 32970769
17. Hossain I, Ahmad SA, Khan MH, Rahman A. COVID-19 and changing behaviors: A cross-sectional online survey among students in Bangladesh. *Eur J Pharm Med Res*. 2020; 7:576–81.
18. Karim A, Akter M, Mazid AT, Pullock OS, Aziz TT, Hayee S, et al. Knowledge and attitude towards COVID-19 in Bangladesh: Population-level estimation and a comparison of data obtained by phone and online survey methods. *MedRxiv*. 2020.
19. Tsodikova O, Korzh O, Hyria M. Information and communication technologies in postgraduate training of primary care doctors: a new look at the problem of using online resources during the Covid-19 pandemic. *Technium Soc Sci J*. 2020; 8:60.
20. Clark R, Freedberg M, Hazeltine E, Voss MW. Are there age-related differences in the ability to learn configural responses? *PloS one*. 2015; 10(8):e0137260. <https://doi.org/10.1371/journal.pone.0137260> PMID: 26317773
21. Knowland VC, Thomas MS. Educating the adult brain: How the neuroscience of learning can inform educational policy. *International Review of Education*. 2014; 60(1):99–122.
22. Brophy JT, Keith MM, Hurley M, McArthur JE. Sacrificed: Ontario healthcare workers in the time of COVID-19. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*. 2021; 30(4):267–81. <https://doi.org/10.1177/1048291120974358> PMID: 33174768
23. Barranco R, Ventura F. Covid-19 and infection in health-care workers: an emerging problem. *Medico-Legal Journal*. 2020; 88(2):65–6. <https://doi.org/10.1177/0025817220923694> PMID: 32441196