Whole-Process Emergency Training of Personal Protective Equipment Helps Healthcare Workers Against COVID-19

Design and Effect

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Objective: To develop an emergency training program of personal protective equipment (PPE) for general healthcare workers (HCWs) who may be under the threat of Corona Virus Disease 2019 (COVID-19) and evaluate the effect of the program. **Methods:** A three-stage training program was designed. The complete clinical workflow together with infectious disease ward was simulated. To verify the effect of the program, an experimental training with pre- and post-test was conducted before large-scale training. **Results:** Post-test scores were significantly improved when compared with the pre-test scores. Among all PPE, N95 respirator and protective coverall needed training most. Meanwhile, ''proficiency level'' and ''mutual check & help'' also needed to be strengthened as independent scoring points. **Conclusion:** This training program significantly improved the performances of participants. It may therefore be applied for general HCWs on a larger scale.

Keywords: Corona Virus Disease 2019, emergency training, personal protective equipment, simulated training

The Corona Virus Disease 2019 (COVID-19) has been prevalent in Wuhan, China since the end of 2019 and has been characterized as a pandemic by World Health Organization (WHO).[1,2] This disease has a high rate of nosocomial infection and healthcare workers (HCWs) are susceptible to it.[3] More than 1000 medical workers have been infected in China and a few of them have died.[4] In order to protect themselves and prevent cross infection, HCWs need to learn how to use personal protective equipment (PPE) correctly.

The disease may cause large-scale infection in a short period of time and bring great pressure to the regional health care system. Many HCWs, no matter what department they work in, have chance to contact patients or their body fluids. Considering the urgency of the situation and the large number of HCWs to be trained, the PPE training for HCWs should be easy to implement while ensuring the effect.

In this study, an emergency training program based on whole-process simulation was carried out in order to help HCWs quickly learn how to use PPE. At the same time, the training effect was evaluated to find out the shortcomings of the program and improve it.

METHODS

This study was conducted in a tertiary hospital in Beijing, China. During the COVID-19 epidemic, it was a designated hospital for confirmed and suspected patients in Beijing. The clinical skill training center of the hospital has simulated wards specialized for infectious disease and complete sets of training equipment. It had organized trainings and drills targeting highly contagious diseases such as Ebola virus disease (EVD) and H7N9 avian influenza.

The clinical skill training center was responsible for the development of the program. After several rounds of discussion, the teachers of the training center determined the content, process, and assessment criteria. There were four full-time teachers and five training assistants undertook the task. All teachers and assistants had received internal training and passed evaluation to ensure that their operations meet the unified standards and they can guide the trainees correctly.

The trainees of this study were HCWs in the hospital, including doctors, nurses, and other personnel (pharmacists, technicians, researchers, etc).

The training process was divided into three sections: (1) lecture and demonstration; (2) simulation exercise; (3) test and evaluation. In the ''lecture and demonstration'' section, a teacher demonstrated each operation of the workflow in different areas of the wards (including the clean area, the potentially contaminated area and the contaminated area) and the trainees followed the teacher synchronously. There were two more assistants on site to provide guidance. In the ''simulation exercise'' section, the participants needed to exercise all the skills in sequence. The teachers and assistants were watching to help them. In the ''test and evaluation'' section, the trainees had to complete the workflow in pairs. The teachers assessed each operation and summarized the total scores. Section 2 and 3 were finished in the simulated ward, where the different areas and buffer rooms were identified with lines on the ground to imitate the real infectious disease ward. Finally, there would be a comment after the assessment.

The training contents were formulated according to the international and national standards.[5–10] The course included donning and doffing of split work clothes, work shoes, and seven kinds of PPE (disposable hat, N95 respirator, goggles, face shield, gloves, protective coverall and boot cover). Meanwhile, hand hygiene and medical waste discarding were also emphasized.

The assessment criteria were discussed and determined by all teachers in advance. In addition to the training contents mentioned

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Clinical Significance: This study demonstrated that an emergency training of personal protective equipment based on whole-process simulation can effectively improve the protective skills of healthcare workers who have chance to contact the COVID-19 patients, and may therefore be applied for larger scale.

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TABLE 1. Characteristics of HCWs Who Participated in Experimental and Large-Scale Training

Characters	Experimental Training ($n = 38$)	Large-Scale Training ($n = 263$)
Gender		
Male	4	21
Female	34	242
Occupation		
Doctor	5	33
Nurse	31	225
Others*	2	5

HCWs, healthcare workers.
*Others include pharmacists, technicians, researchers, etc.

above, proficiency level and mutual check & help were also considered as independent rating points. For each trainee, the final score was the sum of all the items. Each person's achievement was judged independently by two teachers. The full score of the test was 100 and the pass line was set at 90.

In order to assess the outcome of this program, an experimental training was performed before the large-scale training. The trainees in the experimental training were tested before and after the training. The assessment criteria for pre- and post-test were consistent with the large-scale training to ensure comparability.

The data of this study was summarized with Microsoft Office Excel 2010, while the statistical analysis and visualization were completed with R (3.3.1). The threshold of P value was 0.05.

RESULTS

Effects of Experimental Training

The characteristics of trainees in experimental and large-scale trainings are listed in Table 1. For experimental training, the pre- and post-test results are shown in Fig. 1 and the difference between them was very significant ($P = 7.16e{-}15$) according to paired t test analysis. Nearly three quarters (73.68%) of the participants couldn't pass the test before the training, but they all passed after the training.

Performance in Large-Scale Training

The training program was then applied for a larger number of HCWs in batches. The histogram of the test results is shown in Fig. 2. Everyone participated in the training passed the assessment and the average score was 96.71.

Points Deducted for Each Item

In order to assess the training effect more accurately, the average loss for each item in the post-test was calculated and then compared with the loss in pre-test of experimental training. Results were demonstrated in Fig. 3. The post-test scores in experimental and large-scale training were combined to enlarge the sample size.

DISCUSSION

In this epidemic, HCWs in variety of clinical departments are likely to contact patients (or suspected patients) of COVID-19. Therefore it is necessary to develop PPE training programs for general HCWs in hospitals. Considering the highly infectious nature of this coronavirus, the trainings should cover a large number of HCWs in a short period of time. The experience of such trainings should also be shared, because the COVID-19 may become prevalent in many other countries in the world as a pandemic and may occur repeatedly in the future.

In order to improve the generality, this study was designed for common HCWs rather than the workers of infectious diseases

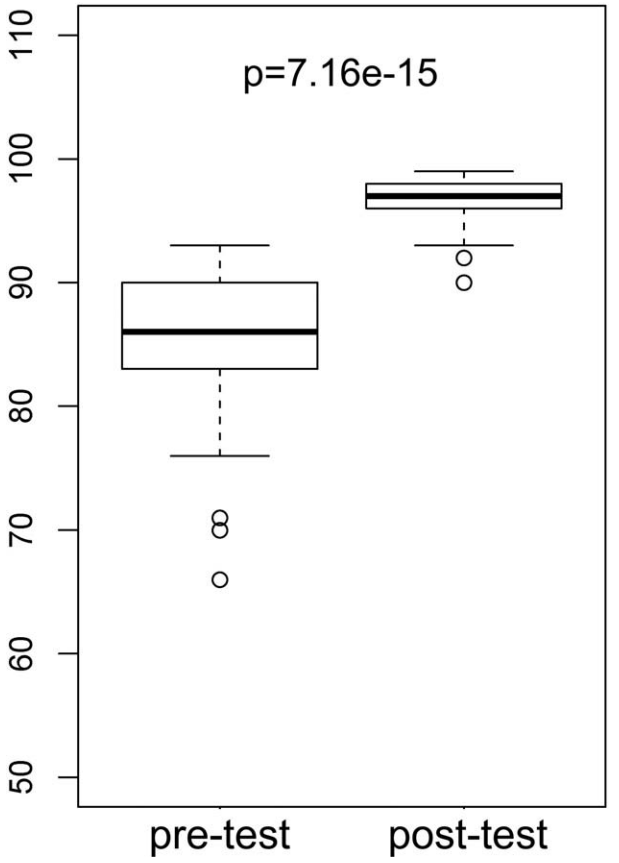

FIGURE 1. Comparison between pre- and post-test scores in experimental training. The performances of trainees were significantly improved after training.

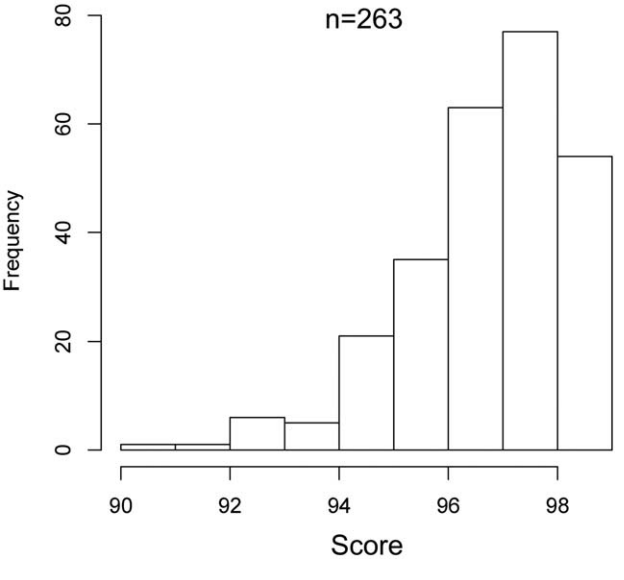

FIGURE 2. Distribution of test scores after large-scale training. All participants passed and the average score was 96.71.

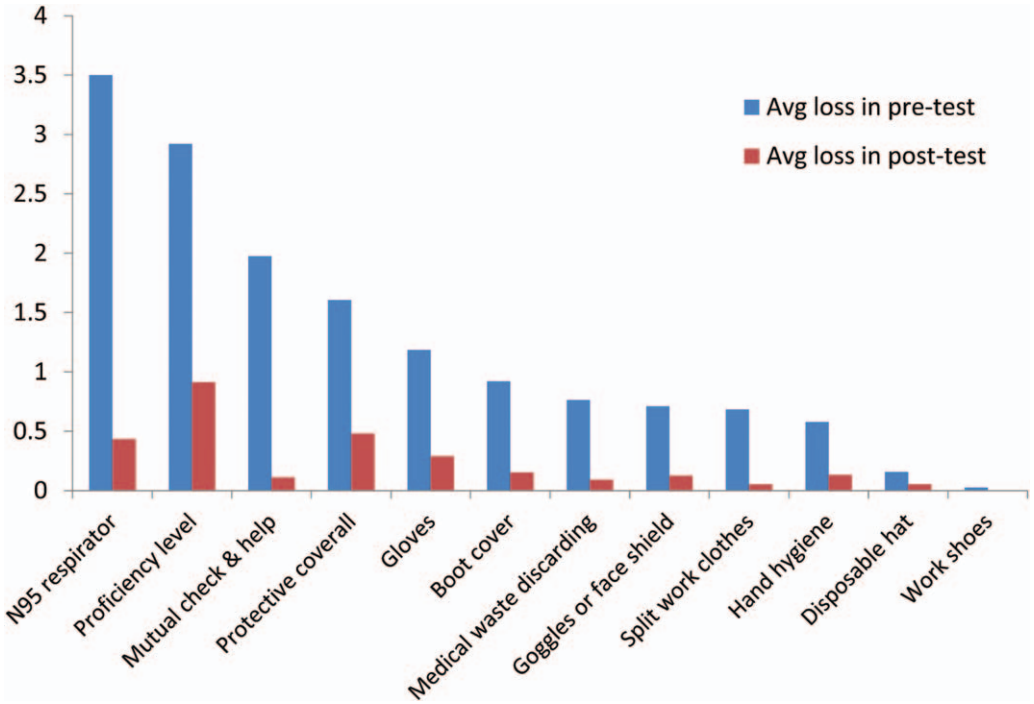

FIGURE 3. Pre- and post-test scores for each scoring item. The post-test scores in experimental and large-scale training were combined.

department. It should be noted that a large part of the trainees have worked or rotated in the infectious disease department before, so the average score of pre-test was relatively high.

According to the WHO guidelines, gowns should be used rather than coveralls when managing COVID-19 patients.[6] In Chinese regulations,[7] gowns or coveralls can be selected under the level-II protection (when entering the place where suspected or confirmed patients with airborne diseases are placed or providing general diagnosis and treatment for such patients); however, under the level-III protection (when conducting aerosol-generating procedures for suspected or confirmed patients), coveralls should be used instead of gowns. When this program was conducting in late January and early February 2020, the transmission modes of COVID-19 were not very clear, so coveralls rather than gowns were taken into the contents of the training.

Among all the items in pre-test, N95 respirator was the one where the highest points were lost (almost 3.5 points for each person averagely), because it is not commonly used. If necessary, HCWs prefer surgical masks in daily work which are more comfortable and breathable. Another PPE easy to lose points was protective coverall, because it is seldom used at ordinary times and both the donning and doffing (especially) are complicated.

In pre-test, there was another remarkable point-deduction in ''proficiency level.'' It suggested that some measures should be taken to help the HCWs to get familiar with the workflow. For example, flow charts or tips can be post in each buffer room. Another item worthy of attention is ''mutual check & help.'' As operations under high protection are relatively dangerous and complex, generally at least two people are required to go in and out at the same time so as to help each other. Many HCWs were not familiar with this work pattern before, but the training has significantly improved their performance in this item.

Simulation-based approaches have been widely used in protective skill trainings against infectious diseases.[11,12] Simulation enables medical staff to get familiar with actual environment and working process. It can also help to identify potential deficiencies.[13–15] But it brings new problems: high fidelity simulation environment needs huge investment and is hard to be applied in other hospitals.[16] In this training process, demonstration, practice and assessment all followed actual workflow. The sites for exercise and test also imitated the layout of infectious disease ward. The high fidelity simulation ward was not used in this study, which helps to shorten the preparation time and lower the threshold for training.

Safety has always been focused on during the training process. Gathering (especially indoors) would increase the risk of transmission, so the number of trainees was limited no more than 20 in a single batch. Participants and teachers were forced to wear masks and the training sites were disinfected every day. The emergency training came at a time when cases began to rise in all provinces of China. In order to support the clinical departments, the hospital's protective equipment was under strict control. The original disposable protective coveralls, boot covers and hats must be reused with regular disinfection.

There are still some deficiencies in this study. This training mainly focused on the donning and doffing of PPE rather than the clinical operations (such as injection, specimen retention, physical examination, etc) with PPE, which was mainly determined by the urgency of the training task. In addition, the powered air-purifying respirator (PAPR) is a kind of important protective equipment especially for the invasive operations.[17] A special training course of PARP has been designed, mainly for the front-line medical workers of respiratory department and intensive care department, but PAPR was not included in this general training program.

CONCLUSION

The rapid transmission of COVID-19 poses a serious threat to HCWs all over the world. Therefore it is necessary to develop PPE trainings for HCWs. This study designed a whole-process based emergency training program that can significantly improve the operation of PPE and other protective skills. The generality and

feasibility of the program were considered, which make it convenient for wide-ranging application (The checklist used in the tests is provided as supplementary data, http://links.lww.com/JOM/A733).

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