



## Major article

## Personal protective equipment for the Ebola virus disease: A comparison of 2 training programs



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### Key Words:

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**Background:** Personal protective equipment (PPE) for preventing Ebola virus disease (EVD) includes basic PPE (B-PPE) and enhanced PPE (E-PPE). Our aim was to compare conventional training programs (CTPs) and reinforced training programs (RTPs) on the use of B-PPE and E-PPE.

**Methods:** Four groups were created, designated CTP-B, CTP-E, RTP-B, and RTP-E. All groups received the same theoretical training, followed by 3 practical training sessions.

**Results:** A total of 120 students were included (30 per group). In all 4 groups, the frequency and number of total errors and critical errors decreased significantly over the course of the training sessions ( $P < .01$ ). The RTP was associated with a greater reduction in the number of total errors and critical errors ( $P < .0001$ ). During the third training session, we noted an error frequency of 7%-43%, a critical error frequency of 3%-40%, 0.3-1.5 total errors, and 0.1-0.8 critical errors per student. The B-PPE groups had the fewest errors and critical errors ( $P < .0001$ ).

**Conclusion:** Our results indicate that both training methods improved the student's proficiency, that B-PPE appears to be easier to use than E-PPE, that the RTP achieved better proficiency for both PPE types, and that a number of students are still potentially at risk for EVD contamination despite the improvements observed during the training.

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Health care workers (HCWs) accounted for up to 25% of Ebola virus disease (EVD) cases during previous outbreaks.<sup>1</sup> In the 2014 epidemic in West Africa, HCWs accounted for 12% of reported cases.<sup>1,2</sup> The foundations of current policy on controlling the spread of EVD in medical facilities<sup>3</sup> include early identification of suspected EVD cases, isolation of those patients in specialized care units, adherence to strict infection control guidelines, and provision of personal protective equipment (PPE).

Despite the importance of PPE measures in protecting HCWs, the use of PPE remains suboptimal or inadequate.<sup>4-7</sup> The insufficient training of medical teams in the proper use of PPE has been

brought under attack,<sup>8</sup> and all previous studies have noted the need to improve performance in the use of PPE.<sup>7</sup> With regard to EVD, cases of contamination of HCWs using full PPE in Europe and the United States have demonstrated the limits of PPE in protecting HCWs.<sup>9-11</sup>

Previous studies have pointed to improved adherence to PPE procedures after training.<sup>12,13</sup> With respect to EVD, current recommendations insist on the need for rigorous and repeated training to achieve proficiency<sup>3,14-17</sup>; however, to our knowledge, the results of these training courses have not yet been formally evaluated.

We conducted the present study to compare 2 different strategies for training students in the proficient use of PPE, as well as to evaluate the frequency and number of errors occurring during donning and doffing of the PPE currently proposed for protecting HCWs against EVD.

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Conflicts of interest: None to report.

## METHODS

### *Study population, period, setting, and design*

Between December 2014 and January 2015, we led training courses on PPE for nursing and medical students. These courses were held in Paris, France, Lima, Peru, and Guadalajara, Mexico in the framework of a teaching project on PPE measures. The students had not received any previous training on PPE for hemorrhagic fevers, but all had received training on standard protective measures. The students were not part of an intended Ebola care team.

### *Ethics statement*

The students volunteered to participate in the training courses. All data were recorded while respecting participants' anonymity. This study was approved by the pertinent Institutional Review Boards (Emergency Committees on Ethics, Research, and Information Systems).

### *Definitions*

We validated the training protocol on the basis of current recommendations.<sup>3,14-17</sup> The PPE used was that available in the countries of the study. We defined 2 types of PPE, Basis pPE (B-PPE) and enhanced PPE (E-PPE), in line with current recommendations.<sup>18,19</sup> B-PPE is currently proposed for use when caring for nonsecreting patients, whereas E-PPE is proposed for patients secreting fluids (eg, hemorrhage, vomiting, diarrhea) with a high risk of soiling and exposure for HCWs. B-PPE includes boots, goggles, surgical mask, and surgical cap, impermeable surgical gown, double gloves, and an impermeable apron. E-PPE includes boots, a full-body impermeable suit, hood with a surgical cap and mask, double gloves, and an impermeable protection apron. B-PPE involves 11 pieces of equipment, 6 steps for donning, and 13 steps for doffing; corresponding numbers for E-PPE are 9, 6, and 12.

For all students, the training program included a 60-minute theoretical course covering EVD epidemiology and clinical features (10 minutes), modes of EVD transmission and prevention strategies (10 minutes), donning of PPE (10 minutes), organization of patient care (10 minutes), and doffing of PPE (20 minutes). The courses used films and slides and were validated by the project's directors of pedagogy.<sup>20</sup>

This theoretical module was followed by a practical course comprising 2 distinct training methods, a conventional training program (CTP) and a reinforced training program (RTP). These training sessions were conducted for B-PPE and E-PPE alike. Thus, 4 groups were constituted: CTP for B-PPE (CTP-B), CTP for E-PPE (CTP-E), RTP for B-PPE (RTP-B), and RTP for E-PPE (RTP-E).

The practical training sessions were based on common principles. Each group consisted of 2 students and 1 trainer, either a nurse or doctor specializing in infectious diseases or hospital hygiene. The sessions were held in a location that simulated a hospital room and an external area comprising a dirty zone and a clean zone. At the end of each session, the students and specialist-trainers duly noted their impressions and the difficulties encountered. The steps of donning and doffing PPE items for 1 student were alternated with those of the other student, to ensure that each student remained clothed in PPE for a given time before proceeding to the doffing phase. Three training sessions were conducted for each group, at intervals of 72 hours.

The detailed breakdown of the practical training sessions is as follows. In the CTP, 2 students dressed while mutually assisting and monitoring each other, then doffed their protective clothing under the same conditions. The specialist-trainer intervened in the event

of an error in technique or in the order of steps, or in case of contact between a student's skin or clothing and a potentially contaminated surface. Should an error arise, the trainer repeated the steps in order and corrected any technical aspects.

In the RTP, the specialist repeated aloud each of the steps and technical skills or processes necessary to perform the task in accordance with standards.<sup>21</sup> Each student executed every step of the donning and doffing process with the supervision and assistance of the other student. In the case of error or imminent error, the specialist-trainer intervened and raised the student's awareness of the importance of following the processes, reinforced knowledge, corrected aspects of technique, and warned of the risk of errors during each step. At the end of the training session, the specialist-trainer debriefed the 2 students on errors made and proposed strategies to correct the problem. In addition, the RTP included a review of each step of donning and doffing, these processes and their objectives, difficulties, and necessary technical skills, as well as a final debriefing that allowed students to take an active role in ensuring their own safety and formulating a comprehensive safety strategy.

During each training session, the specialist-trainer noted the number of errors in order and technique, defined as errors, as well as the number of contacts between the student's skin or clothing and potentially contaminated PPE surfaces, defined as critical errors. The total number of errors is the sum of the 2 types. We measured the frequency and total number of errors for donning and the frequency, total number of errors, and critical errors for doffing. Error and critical error counts were the main outcome measures.

Comparisons were done only for retained quality criteria indicators: for donning, total error percentage and error count, and for doffing, the frequencies of total errors and critical errors, and the counts of total errors and critical errors. During doffing of the gown (B-PPE) and the full-body coat (E-PPE) and of boots (B-PPE and E-PPE), frequency and total number of errors and critical errors were compared. Duration of donning and doffing were recorded (in minutes). There were no other instructions concerning the length of the practical training.

### *Statistical analysis*

We estimated that 30 students per group were required to achieve a statistical power of 0.9 and a .05 significance level. Enrollment in the program remained open until the desired number of students for each group was attained. Two specialist-trainers led 10 sessions for each of the 4 groups, with each specialist-trainer noting errors and critical errors independently. Intrareader and interreader agreements on errors between specialist-trainers were assessed by calculating a  $\kappa$  coefficient between the specialists.<sup>22</sup>

We compared differences among the 4 intervention groups during the first and third training sessions using the paired *t* test for continuous data and the  $\chi^2$  test for categorical data. The Wilcoxon rank-sum test and 2-way analysis of variance were used to compare repeated measures.<sup>23</sup> A 2-tailed *P* value of  $<.05$  was considered statistically significant. All statistical analyses were carried out using Statistica 10 software.

## RESULTS

A total of 120 students were enrolled (30 in each group), including 76 (63.3%) nursing students and 44 (36.7%) medical students. The average age of participants was  $21.2 \pm 3.5$  years, and the male:female ratio was 0.65. Intrareader and interreader agreements were found to be valid for errors (0.89 and 0.81, respectively) and critical errors (0.85 and 0.78, respectively).

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