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Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

The association between self-perceived proficiency of personal protective equipment and objective performance: An observational study during a bioterrorism simulation drill

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Key Words:

Health care workers
 Questionnaires
 Self-report
 Compliance

Background: The recent Ebola virus disease outbreak emphasized the potential misuse of personal protective equipment (PPE) by health care workers (HCWs) during such an event. We aimed to compare self-perceived proficiency of PPE use and objective performance, and identify predictors of low compliance and PPE misuse.

Methods: An observational study combined with subjective questionnaires were carried out during a bio-terror simulation drill. Forty-two observers evaluated performance under PPE. Mistakes were recorded and graded using a structured observational format and were correlated with the subjective questionnaires and with demographic parameters.

Results: One hundred seventy-eight HCWs from community clinics and hospitals were included. The mean self-perceived proficiency was high (6.1 out of 7), mean level of comfort was moderate (4.0 out of 7), and mean objective performance was intermediate (9.5 out of 13). There was no correlation between comfort and objective performance scores. Self-perceived proficiency was in correlation with donning and continuous performance with PPE but not with doffing. Clinic personnel performed better than personnel in hospitals (40.3% vs 67.8% with 3 or more mistakes, respectively; $P = .001$). Demographic characteristics had no correlation with objective or self-perceived performance.

Conclusions: Self-perceived proficiency is a poor predictor of appropriate PPE use. The results suggest poor awareness of the possibility of PPE misuse.

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Protection of health care workers (HCWs) by personal protective equipment (PPE) use and hand hygiene has become a standard practice in modern health care. These measures are stretched to an extreme in the uncommon events of severe contagious diseases outbreaks, which can be the result of a deliberate attack or a natural outbreak.^{1,2} Examples of such outbreaks that occurred since the beginning of the 21st century are the severe acute respiratory syndrome

epidemic,³ the H5N1 avian influenza,⁴ the 2009 H1N1 influenza pandemic,⁵ the recent Ebola virus disease (EVD) outbreak,⁶ the novel influenza A H7N9 virus,³ and the Middle East respiratory syndrome corona virus outbreak.⁷

HCWs are subject to increased risk of infection during an outbreak, but can be well protected by PPE. Nevertheless, the 2009 H1N1 influenza pandemic taught us that knowledge and self-reported compliance to recommended PPE use are suboptimal among HCWs.⁸ More than 850 confirmed HCW infections were reported from Guinea, Liberia, and Sierra-Leone in the recent EVD outbreak with more than 500 reported deaths (see <http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/index.html>). Three cases of nosocomial transmission among apparently protected HCWs in Spain and the United States heightened concerns among health care professionals and decision makers.^{9,10}

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Conflicts of interest: None to report.

Several studies demonstrated that overall adherence to appropriate PPE use while providing care for patients in hospitals was modest, and PPE misuse was frequent.^{11,12} Factors found to be associated with appropriate PPE use were knowledge, training, perception of being afflicted with life-threatening diseases, and personal comfort.^{13,14} Nevertheless, most studies were conducted in a hospital setting and were based on self-reported questionnaires without matched objective observations.⁸ Moreover, studies were not conducted in settings of a severe contagious outbreak in which participants need to combine contact, droplet, and airborne precautions.

We aimed to observe PPE use among HCWs in hospital and outpatient clinic settings to determine whether self-perceived proficiency of PPE use in the setting of a severe contagious outbreak influences objective adherence to protocols and to identify predictors of low compliance and PPE misuse.

MATERIAL AND METHODS

Participants and setting

This was an observational study combined with subjective questionnaires. The platform was the Israeli "Orange Flame" exercise, a national preparedness buildup project conducted by the Israeli Ministry of Health aimed at improving national preparedness for large natural and bioterrorism-associated outbreaks.^{2,15} During the exercise, HCWs in various health settings provide care for hundreds of patient-actors while using PPE, including a disposable gown, face shield, N95 respirator, and nonsterile gloves.²

The study was conducted during November 2014 and included HCWs from 2 tertiary medical centers, 8 civilian community-based primary care clinics, and 2 military primary care clinics. Forty-two fourth-year nursing students observed and evaluated donning, doffing, and continuous performance under PPE in the different health care settings. The observers had no other tasks during the drill, and each trainee was followed by 1 observer. The observers received comprehensive education on PPE use, in accordance with the Centers for Disease Control and Prevention (CDC) guidelines (see <http://www.cdc.gov/ncidod/dhqp/pdf/isolation2007.pdf>) using a detailed checklist (Supplementary Table S1, available on request). The premise of using nursing students as observers is that the students are reliable judges: standard precaution and infection prevention and control (IPC) are included in the nursing core curriculum and are considered to be obligatory skills.

All trainees were HCW professionals, including physicians, nurses, medics, directors, logistics staff, and administrative staff directed to work under contact, droplet, and airborne precautions. The selection of which HCWs to observe was random. The trainees knew about the observers' participation in the drill but did not know which of them observed aspects of infection control.

The study was approved by the Institutional Review Board of the Israel Defense Forces Medical Corps and exempted from informed consent requirements because all participants were aware of the observation and could refuse to participate in the exercise or to fill out the questionnaire.

Data collection and analysis

Data were collected from participating HCWs using a structured self-administered questionnaire. This included demographic parameters, number of lectures on infection control in which the trainee participated during the past 3 years, and a subjective assessment of PPE discomfort and self-perceived proficiency of PPE use based on a Likert-type scale (where 1 = low and 7 = high). The participants were also asked to comment on their own motiva-

tional factors and obstacles to correctly use PPE (Supplementary Table S2, available on request).

The performance scores were based on the objective competency checklist and included donning score, doffing score, and working under PPE score. HCWs received 1 point for every step they correctly performed and zero if a step was incorrectly executed. This scoring technique is based on the Skills Competency Checklist for Contact Precautions of the American Association of Nurse Assessment Coordination (see http://www.aanac.org/docs/2015-ltc-leader/n-coley_capstonefinal.pdf?sfvrsn=2) and adjusted to contact, droplet, and airborne precautions requirements during a severe contagious disease, in accordance with CDC guidelines as mentioned earlier. The ranges of these scores are 0-12, 0-6, and 0-13 for donning score, doffing score, and working under PPE score, respectively. Overall, every individual participant received 3 different performance scores (for donning, doffing, and working under PPE) and each performance score was based on the sum of steps that were properly completed by the participant (Supplementary Table S3, available on request).

Statistical analysis

Data were analyzed using BMDP Statistical Software (Statistical Solutions Ltd, Boston, MA). Between-group differences of discrete variables were analyzed using the Pearson χ^2 test or Fisher exact test, as applicable. Because the PPE scores did not have Gaussian distributions, they were compared using the nonparametric Mann-Whitney *U* test. Correlations were computed using Spearman's correlation. $P \leq .05$ was considered significant.

RESULTS

Characteristics of participants

Overall, 178 HCWs were observed in the study. Characteristics of the participants are presented in Table 1. The average time of working with full PPE was 73.3 minutes (range, 17.0-156.0 minutes). Sixty-five percent worked in tertiary medical centers (the hospital group) and 35% worked in primary health care settings (the clinic group).

PPE scores and objective parameters

One hundred seventy-seven HCWs were observed while donning and working under PPE and 166 were observed while doffing PPE. The mean PPE scores \pm standard deviations were 9.82 ± 2.63 (out of 12; median = 11), 3.69 ± 2.06 (out of 6; median = 4), and 9.49 ± 2.69 (out of 13; median = 10) for donning, doffing, and working under PPE, respectively. The most common errors regarding PPE misuse were the N95 respirator flexible bands were not fastened to the nose bridge (37.2%), gloves did not cover the wrists (26.9%), and N95 respirators did not cover the nose (20.4%). In addition, 26% of HCWs with long hair did not collect the hair while donning PPE, and 41.2% did not change gloves between patients. Moreover, doffing the PPE not according to CDC guidelines was observed in high rates with all PPE items (26.5%, 42.8%, 41%, and 35.5% for gloves, face shields, gowns, and N95 respirators, respectively). Fifty-five percent used designated placards while donning and 46% used designated placards while doffing. Using the placards improved donning and doffing sequences but did not influence the PPE scores. Hand hygiene and disinfection were observed in 164 out of 178 HCWs. Proper hand hygiene protocol was followed by 51.8% (disinfection and then drying of the hands), 16.5% disinfected the hands but did not properly dry them, and 31.7% did not follow the hand hygiene protocol at all. Proficiency scores were significantly higher for participants in the clinics

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