



## Major Article

# Use of personal protective equipment among health care personnel: Results of clinical observations and simulations



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## Key Words:

Health care personnel  
Personal protective equipment  
Contamination  
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Videotape analysis  
Fluorescent powder

**Background:** Very little is known about how health care personnel (HCP) actually use personal protective equipment (PPE).

**Methods:** The clinical PPE practices of 50 HCP from selected units at the University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital were videotaped with HCP consent. For 2 PPE simulation sessions (simple and full-body sets), 82 HCP were recruited throughout the UPMC system. Simulation practices were videotaped and examined using fluorescent powder with ultraviolet lighting. All participants completed an electronic survey. For a follow-up evaluation simulation, 12 HCP were recruited among simulation participants.

**Results:** Among 130 total sessions from 65 participants, contamination occurred in 79.2% of simulations during the doffing process with various PPE items: simple set (92.3%) and full-body set (66.2%). Among 11 follow-up evaluation participants, contaminations still occurred in 82% after receiving individual feedback, but the overall contamination level was reduced. Using the contamination information gained during the simulation analysis, 66% of potential contamination was estimated for the clinical observation. Concerns and barriers in PPE use from HCP survey responses were as follows: time-consuming, cumbersome, and PPE effectiveness.

**Conclusions:** Although HCP knew they were being videotaped, contamination occurred in 79.2% of the PPE simulations. Devising better standardized PPE protocols and implementing innovative PPE education are necessary to ensure HCP safety.

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## BACKGROUND

The 2014 U.S. Ebola cases in nurses that resulted from occupational exposure underscored that health care personnel (HCP) are at risk for contracting infectious diseases during patient care. Despite

the Ebola transmission route (ie, contact with body fluids) being relatively clear, 2 U.S. nurses were infected with Ebola during patient care despite their wearing of full-body personal protective equipment (PPE). Cable News Network reported inconsistencies in the type of PPE worn and the procedures of donning and doffing PPE during patient care as possible causes of the first nurse's Ebola infection.<sup>1</sup> This emphasizes that very little is known about how HCP actually use PPE in their daily practice.

Although updated PPE guidelines were released during the Ebola outbreak, some discrepancies still exist among them. For example, regarding the donning of PPE for Ebola preparedness, the Centers for Disease Control and Prevention (CDC) training modules state that “if your gown does not have thumb hooks, some facilities may consider taping the sleeve of the gown over the inner glove to prevent potential skin exposure from separation between the sleeve and inner

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glove during activity.”<sup>2</sup> However, World Health Organization guidelines prohibit the use of tape to seal any exposure between gloves and gowns because of the potential for contamination during the removal process.<sup>3</sup> During Ebola outbreak readiness preparation in 2014, most U.S. tertiary hospitals developed tailored protocols and trained HCP in using PPE. However, such protocols were imperfect because of a lack of sufficient quantities of PPE (eg, hazmat suits, impermeable gown, face shields), and many HCP were directed to video, paper, or online sources to learn proper PPE use.<sup>4</sup> The existing discrepancies between CDC guidelines and actual hospital protocols (eg, those of Emory Healthcare) have led infection preventionists to call for clear PPE use protocols and procedures for Ebola.<sup>5</sup>

Until the Ebola outbreak received widespread attention with calls for development of a resource-intensive preparedness response (eg, full PPE and a trained observer system), problems regarding general PPE use had not been examined in depth. Although PPE is an essential part of isolation precautions to protect both HCP and patients from exposures to infectious agents, PPE compliance in hospitals may not have received the same emphasis as hand hygiene compliance, which is known to be the most effective intervention in preventing disease transmission. Because PPE is only effective when used correctly, both PPE noncompliance and poor donning and doffing processes can result in transmission of infectious disease. However, PPE monitoring in hospital settings is usually limited to yes or no compliance<sup>6</sup> that is not extended to verification of actual competency in PPE donning and doffing procedures. In fact, effective PPE use in clinical settings involves a complex matrix of variables, such as PPE availability at a patient’s room; PPE type, size, and quality; intended procedure; HCP task burden (eg, number of assigned patients); level of potential exposure; and work environment. For optimal PPE use, HCP competency in donning and doffing PPE alone is insufficient. Rather, it must be complemented by the necessary system-level support, such as leadership, policies, teamwork, training efforts, and safety culture.

Given the lack of a clear and highly standardized protocol for PPE use, the goal of this study was to enhance safety for both HCP and patients by providing evidence (1) to establish a standardized protocol for optimal PPE use and (2) to optimize an educational intervention across health care facilities and in professional health schools. To achieve this goal, this study aimed (1) to describe the knowledge, attitudes, and practices of HCP on PPE use; (2) to assess the performance of HCP regarding PPE procedures with different types of PPE; and (3) to identify potential breaches in and barriers to PPE compliance.

## METHODS

This study was designed as an observational, descriptive study in 4 parts: a clinical observation, a simulation observation, a survey (for both clinical and simulation participants), and a follow-up evaluation simulation. Simulations required HCP to don and doff diverse PPE types for each item (eg, N95 respirator—pouch vs flat-fold vs cup style) in 2 levels of sets (ie, simple set [basic PPE items, such as daily use PPE in clinical setting], full-body set [enhanced protection PPE items, such as in Ebola preparedness]). With the University of Pittsburgh Institutional Review Board approval, both survey and videotaping observation methods were used for data collection.

### Survey

Survey questions were developed using the Qualtrics survey system (Qualtrics, Provo, UT) for collecting the necessary information from HCP, such as profession, sex, age, PPE experience year, PPE

use frequency, PPE education experience, beliefs on PPE effectiveness, perceptions of cumbersomeness in PPE use, and confidence in using PPE (in general, simple set, and full-body set). In addition, open-ended survey questions were included to reflect HCP opinions about barriers, concerns, and suggestions for PPE use in their practices. The survey questions developed were reviewed by 2 study task force team members (B.C. and K.J.S.) and were pilot-tested by 3 infection preventionists from Three Rivers/Pittsburgh APIC Chapter (TRAPIC) for content clarity and appropriate wording.

### Clinical observations

The clinical observation portion of this study was conducted at the UPMC Presbyterian Hospital, a 762-bed tertiary care facility, from August 31–September 11, 2015. Clinical observation subjects (ie, HCP who visited patients on isolation) were recruited at selected units that had every tenth isolation patient location on a daily report, which listed all isolation patient rooms in the hospital. The report was generated during the study period by a UPMC system infection control coordinator (B.C.) during the study period. A trained research assistant visited the selected units, recruited HCP, obtained consent for research participation, videotaped the PPE performance (both donning and doffing) of HCP, and asked HCP to complete an online survey using a tablet computer. Through the additional survey questions, study participants for clinical observation were able to choose (1) to receive feedback on their observed PPE practices and (2) to participate in the simulation portion of this study. Because fluorescent powder could not be used on patients in an actual hospital setting, clinical observation videos were analyzed based on simulation analysis results to find potential contamination opportunities.

### Simulations

The simulation portion of this study was conducted at the University of Pittsburgh, Peter M. Winter Institution for Simulation, Education, and Research from September 22–November 10, 2015. Subjects were recruited through the UPMC system and the University of Pittsburgh School of Nursing, through an introduction at the UPMC Presbyterian Hospital Nursing Grand Rounds, through e-mail advertisements, and by posting flyers on the UPMC intranet and bulletin boards located at the hospital coffee shop and nearby elevators. All HCP, across all disciplines (eg, doctor, nurse, nurse aid, technician), who participated in patient care at UPMC, were eligible to participate in the study. To encourage research participation in the simulation portion, an incentive (ie, \$45) was provided.

During each simulation, participants completed (1) a written consent form, (2) a first simulation session with a randomly assigned simple PPE set, (3) a second simulation session with a randomly assigned full-body PPE set, and (4) an online survey. Various styles of each PPE item were randomly combined by taking 1 sample among each different PPE available from each category in order: disposable gown (yellow gown vs blue surgical gown vs impermeable gown), surgical mask (antifog vs chamber style), N95 respirator (pouch style vs flat-fold style vs cup style), gloves (long sleeve vs short sleeve), cap (bouffant vs surgical), full-body gown (hazmat suit vs 2 disposable gowns for dual covering front and back), hood (pullover vs long vs short), face shield (mask with shield vs face shield), eye protection (goggle vs glasses style), and shoe cover (boot cover vs shoe cover). In addition, a powered air purifying respirator (PAPR) was used as in Ebola preparedness as part of some randomly assigned full-body PPE sets.

Simulation participants’ PPE donning and doffing procedures were videotaped simultaneously using both a tablet computer and simulation room cameras to avoid missing any parts of the PPE

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