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Major article

Environment and body contamination: A comparison of two different removal methods in three types of personal protective clothing

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Background: This study aimed to examine the body contamination rates and environmental contamination levels during the removal of 3 types of personal protective clothing (PPC) by the individual accustomed removal method (IARM) and gown removal methods recommended by the Centers for Disease Control and Prevention (CDC).

Methods: Fifty participants performed IARM and CDC-recommended gown removal methods to remove 3 types of PPC (ie, cotton gown, water resistant gown, and plastic apron) in random order at 2 separate sessions after applying Glo Germ simulated germ lotion on the gown's surface. A video demonstrating the CDC-recommended gown removal method was shown between the 2 sessions. After PPC removal, fluorescent stains were counted by an ultraviolet scan under dim light.

Results: Following IARM, contaminants were splashed in the surroundings, particularly on the front part of the subject. The plastic apron and cotton gown obtained the highest and lowest contaminative hazards, respectively, to the hands, shoes, and environment. Females, nurses, and senior staff had serious hand or shoe contamination. The CDC removal method more significantly reduced body and environmental contamination of small fluorescent stains (<1 cm^2), but not of large patches (>1 cm^2), than IARM.

Conclusion: The effect of gown removal, PPC type, discarding PPC location, training of infection control measures, hand hygiene, and special work shoes should be considered daily.

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Standard precautions have suggested that hand hygiene and the use of appropriate personal protective equipment (PPE) to prevent the transmission of pathogens among patients and HCWs (HCWs) should be an essential part of routine nursing care.[1] The Center for Health Protection in Hong Kong recommends that HCWs wear an isolation gown or apron when anticipating a splashing procedure and when a large part of their clothing might come into contact with patients or their immediate environment.[2]

Using protective clothing is one of the most effective strategies to prevent cross infection in such a situation.[3,4] However, an isolation gown or apron can be contaminated when the wearer cares for a patient colonized or infected with infectious pathogens.[5,6] Casanova et al[7] showed that the body of the subject, especially the dorsum of the hands, is contaminated and virus transfers to the hands and clothing during PPE removal. Zamora et al examined the self-contamination rates when removing 2 personal protective systems and found that the anterior neck, forearms, wrists, and hands were the likeliest zones for contamination.[8] Similarly, Wong et al[9] conducted a simulated viral load test and observed contamination sites on the subjects' face, dorsum and palm, and trunk. These studies mainly focused on the body self-contamination rates. However, environmental contamination levels during PPE removal were not known. Our recent study examined both body contamination rates and environmental contamination levels and revealed that the front part of the subject and the rubbish bin were contaminated during the removal of latex gloves.[10] However, the study did not involve personal protective gown.

The outbreak of severe acute respiratory syndrome in 2003 alerted HCWs to the fact that they had to comply with protocols of donning and removing personal protective clothing (PPC) to minimize risk of infection by the disease among HCWs.[11] PPC

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should be removed before leaving the patient care area to prevent possible contamination of the environment outside the patient's room in a manner that prevents contamination of clothing or skin, and an accurate process has been delineated by the CDC-recommended removal method.[1] Our recent study examined 2 different methods of removing gloves and found that the CDC gown removal method significantly decreased the rate of contamination of the environment and HCWs.[10] The aforementioned studies of Zamora et al[8] and Wong et al[9] did not follow the CDC protocol. Casanova et al[7] adopted the CDC protocol during PPE removal but did not compare with individual accustomed removal method (IARM).

Woven and nonwoven isolation gowns are available in clinical settings. Wong et al[9] found that the physical material properties of these gowns differ and suggested that the traditional surgical woven gown absorbs liquid contaminants, whereas the nonwoven gown resists them. However, no concrete evidence indicates the level of contamination of the environment and body caused by different methods of removal of different types of PPC. Considering that, until present time, studies about both body contamination rates and environmental contamination levels, and 2 methods during removal of different types of PPC have not been very full-scale, the present study aimed to examine the body contamination rates and environmental contamination levels during 2 different methods (IARM and CDC-recommended gown removal method) of removing 3 types of PPC (cotton gown, water-resistant gown, and plastic apron). We hypothesized that (1) IARM and CDC-recommended gown removal methods have different effects on body contamination rates and environmental contamination levels; (2) a significant difference in contamination levels during the removal of the 3 types of protective clothing can be observed between the 2 removal methods; and (3) reduced environmental and bodily contaminations are associated with the CDC-recommended gown removal method.

METHODS

Subjects

Fifty HCWs were recruited for this study. Because a high number of health care staff comprise females, 34 (68%) subjects were female, and 16 (32%) were male. The 50 subjects included nurses (n = 20, 40%), support staff (n = 15, 30%), doctors (n = 10, 20%), and allied health workers (n = 5, 10%). The average age was 32.9 years at a range of 22 years to 50 years (standard deviation ± 5.7). The average working experience was 10.9 years at a range of 2 years to 24 years (standard deviation ± 5.1).

All HCWs were given information about the purpose and procedures of the study. Written consent was obtained prior to the study. Ethical approval was obtained from the Human Subject Ethics Sub-committee of the Hong Kong Polytechnic University and the Clinical Research Ethics of the Joint Chinese University of Hong Kong and New Territories East Cluster before the study was conducted.

Sample size

Sample size was determined by reference to another study.[8] The standard deviation of the small patch of fluorescent stain (<1 cm^2) on the front of doffed gloves in the post-test and pretest was 7.65. The clinically relevant difference (δ) was 6.7 (pretest small patch, 15.9; post-test small patch, 9.2). The significance level (α-2-sided) was .05. Power in the experimental study design was (1-β) and should not be lower than 0.8.

According to Fang,[12]

$$N = \left[\frac{2\left(\mu_\alpha + \mu_\beta\right)\sigma}{\delta}\right]^2$$

Therefore,

$$N = \left[\frac{2(1.64 + 1.28)7.65}{15.9 - 9.2}\right]^2 = 45$$

As a result, each removal method for each gown required 45 samples. Fifty subjects were required in case of any possible error in the study. Each of the 50 subjects was required to test 3 types of protective clothing following 2 different removal methods.

PPC

Table 1 illustrates the 3 kinds of PPC used in the experiment: PPC1: Disposable water-resistant gown. PPC2: Reusable cotton gown. PPC3: Disposable plastic apron. The anticipation of fluid contaminant during the procedure determined the type of isolation gown used. PPC was evaluated (Table 1).

Testing of PPC fabric characteristics

Fabric characteristics, including weight, thickness, fabric water repellency, and fabric liquid penetration, were evaluated. The fabric face was measured for water repellency and wettability. A spray test was completed according to American Association of Textile Chemists and Colorists standard 22.[13] Grade 5 indicates no sticking or wetting of the upper surface (ie, maximum water repellency), whereas a 0 indicates the complete wetting of the entire upper and lower surfaces (ie, the poorest water repellency). The liquid penetration test was performed according to American Association of Textile Chemists and Colorists standard 127.[14] For liquid penetration pressure, a zero value reflects no resistance to liquid water penetration under 60 mbar/min of the hydrostatic pressure of liquid water. The maximum value is 999 mbar/min, reflecting the highest resistance to liquid water penetration. The mean fabric physical characteristics are listed in Table 1.

Simulated germ lotion

Using fluorescent lotion to reproduce contaminants in assessing contamination rate is effective and can be utilized for comparison with body and environment contamination levels.[8-10] Therefore, a fluorescent powder (Glo Germ Co, Moab, UT) especially developed for determining hand hygiene compliance was used in this study. The Glo Germ powder was mixed with light olive oil and water to resemble human aerosol as closely as possible.[15] The Glo Germ powder is 100% synthetic organic colorant A-594-5 (blaze orange or invisible blue are the 2 available colors) with 5 microns or smaller particles, which is similar to bacteria size. Assuming that the density of the solution is 1, the weight of the splash in 5 strokes was 3.8 g as determined by an electronic analytical balance. The precision of the balance was 0.01 g.

Ultraviolet lamp

Ultraviolet (UV) light (model: OT4-JX with power of 220 V and 50 Hz; Tongxiang Datang Photoelectricity Technology, Tongxiang, Zhejiang, China) (Fig 1) is a useful tool to detect the fluorescent stains of contaminations on the body of the wearer, the PPC, and the surrounding environment. The UV lamp was tested and checked

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