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Editorials

A highly precautionary doffing sequence for health care workers after caring for wet Ebola patients to further reduce occupational acquisition of Ebola

Mary-Louise McLaws DipTropPubHlth, MPH, PhDMed [a,*], Abrar A. Chughtai MBBS, MPH, PhD [a], Sharon Salmon BN, MPH [a,b], C. Raina MacIntyre MBBS, MAppEpid, PhD [a]

[a] School of Public Health and Community Medicine, UNSW Australia, Sydney, NSW, Australia
[b] Infection Control Team, National University Hospital, Singapore

Ensuring the safety of health care workers (HCWs) is the aim of all work health and safety (WHS) principles regardless of which country the health setting is located.[1] For an infection with a high case fatality rate, it is paramount that WHS principles for HCWs are fail-safe because failure to protect HCWs from contamination during the doffing (removal) of contaminated personal protective equipment (PPE) may be fatal.[2-4] During the 2014-2015 Ebola virus disease (EVD) epidemic, unexplained occupational acquisition of EVD by HCWs and the contribution made by breaches in doffing protocol was debated.[3] In the absence of firm evidence of the degree that faulty doffing contributed to occupational acquisition of EVD, the doffing sequence must be designed to reduce potential exposure to contaminated PPE to zero. This is especially the case given EVD has a low infective dose, between just 1 and 10 viral particles.[4] Doffing PPE after caring for wet (bleeding, vomiting, and diarrhea) EVD patients means the margin of error for transmission during doffing PPE must be zero. Regardless of whether the EVD patient receives care in a high or low resourced health care setting, the high viral load found in explosive vomitus and diarrhea of wet EVD patients contributes to the risk of occupational acquisition.[3] The basic reproductive number of EVD (R0) in Africa has been estimated to be 2, and the mortality rate of EVD is estimated at 70%.[5] The last global outbreak with life-threatening implications for HCWs was sudden acute respiratory syndrome (SARS) in 2003, which had an estimated R0 of 1.2-3.6 and a mortality rate of approximately 10%.[6-8] Regardless of the country where HCWs are at risk of acquiring SARS or EVD from their patients, both diseases have mortality rates that are orders of magnitude higher than pandemic influenza or other infections we are trained to deal with. For example, the highest estimated case fatality of the 2009 pandemic influenza virus was 0.18%.[9]

We reviewed video guidelines and guidelines considered to lead infection control globally[10-12] and a modified Centers for Disease Control and Prevention (CDC) video[13] and a local video from the New South Wales Ministry of Health.[14] Each video was reviewed with the intent of identifying exemplary doffing for the principle that no used PPE surface should come into contact with mucous membranes, face, or hair. Our review identified a lack of consensus for 3 critical areas: sequence, assistance, and environment (Table 1). Exemplary practices from each video that would assist in reducing the risk of occupationally acquired EVD are listed in Table 2.

Outbreak response requires adapting to situations and new knowledge as these unfold,[15] regardless of health care setting. We know face-touching is a common unconscious practice in the community,[16] and in HCWs this may increase with heat and the discomfort generated from wearing plastic aprons, gloves, shoes covers, hair cover or cap, water-resistant mask, and face shield.[17] After 2 occupationally acquired cases of EVD, recommendations in the United States moved away from surgical masks to wearing disposable N95/P2 masks together with a face shield and to powered air purifying respirators (PAPRs) to improve comfort, tolerability, and safety[10,17] that remove the risk of HCWs face-touching with contaminated gloved hands. The ramping up of PPE by the CDC[18] with a surgical hood, coverall, and PAPR is understandable for wet EVD patients given viral load is high in the excreted body fluids. Regardless of whether PAPRs or N95/P2 masks are used, there is a high likelihood that HCWs caring for wet EVD patients will have their PPE contaminated with explosive vomitus and diarrhea high in viral load especially around the torso. However, the gains in risk reduction with the introduction of PAPR may be offset by risk for occupational acquisition through the exposure of vulnerable facial mucous membranes to microscopic sprays from highly contaminated apron and coveralls. The Médecins Sans Frontières video illustrates spraying the heavy duty apron with bleach, but later sequencing of the removal of the facial protection would improve the margin of error. For the removal of boots, that have already been decontaminated in a 0.5% chlorine footbath but that may have become recontaminated during doffing of coveralls, the North

* Address correspondence to Professor Mary-Louise McLaws, School of Public Health and Community Medicine, UNSW Australia, Level 3 Samuels Building, Sydney, NSW 2052, Australia.
E-mail address: m.mclaws@unsw.edu.au (M.-L. McLaws).
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Table 1
Doffing sequences observed in videos

	CDC[10] PAPR	CDC[10] N95 + hood + face shield		North Carolina[13] N95 + hood + face shield	CEC[14] N95 + hood + face shield	MSF[11] N95 + hood + face shield, heavy duty apron
Critical Areas	Gown/coverall	Gown	Coverall	Coverall	Gown	Coverall
Doffing under supervision						
Active assistance inside doffing area	Yes	Yes, with specific items	Yes, with specific items	Mostly passive at 1 m from HCW, may wipe down visible contaminants on PPE	Passive only	Passive, but may actively decontaminate PPE
Wears gown or coverall, face shield, double gloving, shoe cover	Yes	Yes	Yes	Yes	No PPE	Yes, apron and N95, goggle instead of face shield
Doffing environment						
Dirty and clean zones demarcated by visible line	No	No	No	Yes	No	Yes
Clean chair/stool for disinfecting washable shoe surfaces/boot covers and floor mat	Yes, no mat	Yes, no mat	Yes, no mat	Predoffing area 0.5% chlorine bath, absorbent walk-off mat	No	No
Dirty chair/stool for removal covers/boots; impervious stool cover and floor mat	Yes; no	No	No	No	Yes; yes	No
Hands-free ABHR delivery system for disinfection of gloves and hands	Yes	Yes	Yes	Hands-free soap and water wash, except ABHR for final hand hygiene	ABHR not hands-free; soap and water or ABHR for final hand hygiene	Bleach solution, clean water for face wash
Shower, clean scrubs	No	No	No	Yes	Yes	
Doffing sequences						
Predoffing boot decontamination	No	No	No	Yes, predoffing 1 min 0.5% chlorine bath with walk-off mat; yes, soap and water wash, after inspecting PPE for visible contamination; yes	No	Yes, sprayed with chlorine
Predoffing glove disinfected and tear check	Yes	Yes	Yes		Yes	Yes
Disinfects outer gloves	Yes, no drying time	Yes	Yes	Yes, using water wash, no drying time	Yes, air dry gloves	Yes, discards; disinfects inner gloves
Apron removal	Yes, with assistance to untie	Yes.	Yes	No	Yes	Yes
Disinfects and discard outer gloves	Yes	Yes, does not discard	Yes	No	Disinfects outer gloves, air dried, not discard	Does not disinfect inner gloves
Remove boot covers/shoe covers on mat	Yes, may have assistance	Yes	No; Yes, no drying time, discards only if contaminated or torn		Yes, impervious floor and stool mats; yes	No
Disinfects and discard inner gloves	Yes, only discard if gloves contaminated or torn	Yes, outer gloves and discards				

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