Human Factors Evaluation of Simulated Ebola Virus Disease Patient Scenarios: System Factors Associated with Donning and Doffing During Triage, Treatment and Transport

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Human Factors Evaluation of Simulated Ebola Virus Disease Patient Scenarios: System Factors Associated with Donning and Doffing During Triage, Treatment and Transport

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Executive Summary

Alberta Health Services (AHS) Infection Prevention and Control (IPC) contracted the W21C, a research and innovation enterprise at the University of Calgary, to conduct a Human Factors evaluation examining the potential transmission of Ebola virus (EV) to health care workers (HCW). The priorities for evaluation were: 1) donning and doffing procedures and 2) potential EV exposure associated with triage, treatment and transport.

To gain an understanding of current IPC practices for AHS staff who interact with Ebola Virus Disease (EVD) patients, the W21C Human Factors team reviewed the literature on EVD and EV transmission dynamics, then observed and recorded seven simulated EVD patient scenarios. These simulation scenarios were held between October 27th and December 9th 2014, involving AHS staff from multiple tertiary acute care sites and departments in AHS' Calgary Zone. Leads from eSIM, Emergency Disaster Management (EDM) and Emergency Medical Services Patient Care Simulation (PCS) were responsible for organizing and managing the simulation scenarios.

The W21C Human Factors team analyzed the observational data to identify situations in which HCW actions and associated events could contribute to potential EV contamination. This analysis was informed by consultation with subject matter experts, literature review and the expertise of the Human Factors team. Findings relating to potential HCW exposure to EV are presented, followed by a discussion of recommendations targeted at system factors that may have contributed to the findings.

Findings

Analysis of the observational data, participation in the simulation scenarios and literature review led to the following findings relevant to potential HCW exposure to EV:

- Variation in design and content of procedural aids used to guide donning and doffing
- Variation in design and configuration of donning and doffing areas
- Inconsistency between the content and layout of donning carts, and procedural aids
- Variation in the type of Personal Protective Equipment (PPE) available to HCW
- Gaps in coverage and fit of PPE
- Deviation from the recommended donning and doffing procedure
- Variation in the time taken to don and doff PPE
- Flow of materials and HCW between hot and warm zones
- Self-reports of heat strain from HCW while wearing PPE
- Out of sequence doffing between Buddies and HCW
- Breaches in PPE, and HCW slipping and falling, while doffing
- Improper disposal of PPE and scissors during doffing
- Contamination of HCW during doffing from people, equipment or the environment
- Self-contamination of HCW from contact with mucous membranes and sharps

Recommendations

These findings were evaluated with an emphasis on the underlying system factors that could have contributed to their occurrence. System factors were grouped thematically as: 1) Policies and Procedures; 2) Equipment; or 3) Environment. Recommendations were developed to reduce the risk of HCW EV contamination through changes to the following system factors.

Policies and Procedures

- **Procedural Aids and Checklists**
  - Design checklists using the Call-Do-Respond or Challenge-Respond method
  - Design checklists and procedural aids consistently with design guidelines
  - Use checklists as cognitive and not instructional materials
  - Standardize the design of checklists across the organization
  - Ensure consistency between checklist terminology and real world references
  - Develop checklist content through formal task analysis
  - Ensure checklists undergo Human Factors usability testing
  - Supplement checklists with equipment redesign and education
- **Doffing Procedures**
  - Design the doffing process to minimize contact between the Buddy and HCW, and between HCW and their own skin and scrubs
  - Provide equipment to help Buddies and HCW self-monitoring during doffing
- **Roles and Responsibilities**
  - Define and formalize the roles and responsibilities of HCW, Buddies, IPC Monitors
  - Implement an Onsite Manager based on the recommendations of the Centers for Disease Control and Prevention (CDC) and Médecins Sans Frontières (MSF)
  - Ensure doffing HCW are supervised by IPC professionals or other highly trained individuals
  - Assign the responsibility of monitoring for high risk actions or events, such as face touching, breaches in PPE, heat strain, to every HCW or staff member
- **Training**
  - Conduct a training needs analysis to determine trainee characteristics, trainer characteristics and methodologies, and to define content design
  - Provide repetitive hands-on training in realistic conditions to support the development of muscle memory and procedural competency
  - Align training strategies with recommended training principles
  - Train specifically for knowledge and skills related to task performance and risk management associated with managing an EVD patient

Equipment

- **Personal Protective Equipment**
  - Provide PPE that is appropriately sized for the population, encompassing the 5th percentile female and 95th percentile male
  - Address gaps in PPE coverage by purchasing appropriately designed PPE as opposed to re-purposing available items
  - Avoid the use of adhesives that may tear PPE
  - Provide anti-fogging solutions and hands-free communication devices to manage sensory impairment associated with wearing PPE
  - Provide support and back-up so that HCW can doff promptly
  - Label PPE with entry times, and HCW names and roles
- **Donning Carts**
  - Restrict items on the donning cart to those items needed for donning
  - Organize the donning cart consistently with associated materials
  - Label and colour code the location of items on the donning cart
  - Cluster associated equipment on multi-purpose carts used to support more than one task
- **Biomedical Waste Containers**
  - Select biomedical waste containers with consideration for physical space and the frequency with which containers can be removed and emptied
  - Select biomedical waste containers with openings that allow HCW to dispose of doffed PPE without contacting the outside of the container
  - Determine the amount of PPE that will fill a biomedical waste container, define the number of HCW who can doff before the container is full
  - Mark biomedical waste containers to indicate their maximum volume
  - Assess the risks of compressing PPE in biomedical waste containers, and provide the appropriate tools for compression if compression is advised
  - Place containers for sharps disposal within reach of doffing HCW

Environment

- **Emergency Departments**
  - Equip patient isolation rooms so patients are comfortable while waiting for care
  - Ensure ED spaces allow HCW to move to a 4 meter distance from the suspected EVD patient, without occluding a point of exit
  - Equip isolation areas with two-way, hands-free audiovisual communication
  - Standardize and document the location and setup of the ED spaces necessary for a suspected EVD patient

- **Intensive Care Unit Patient Rooms**
    - Use physical barriers to separate hot and warm zones, and clean areas
    - Design spaces to maintain the clean in/dirty outflow with separate entrances and exits
    - Demarcate HCW workstations within the patient room as within the hot zone
    - Frequently decontaminate high contact surfaces, such as door handles, hands-held communication devices and IV pumps
    - Ensure doffing areas are not placed in high traffic areas where contamination could accumulate in the environment and on equipment
- **General Environmental Considerations**
    - Design spaces to allow adequate clearance between HCW and equipment, the physical environment and other HCW
    - Ensure donning and doffing spaces are large enough to allow the 95th percentile male full range of motion
- **Equipment for Donning and Doffing**
    - Ensure donning and doffing areas are equipped with:
        - Wall-mounted hand sanitizers for designated areas, and portable hand sanitizers for 'impromptu' areas
        - Appropriately sized chairs with a fixed base
        - Mirrors for HCW and buddies to observe donning and doffing
        - Hands-free audiovisual communication devices
    - Provide easily cleaned workspaces each for hot, warm and clean zones
    - Ensure physical barriers are available if needed to separate clean and dirty zones
    - Standardize visual markers, such as tape, that demarcate hot and warm zones
    - Ensure clean scrubs and hydration are available for HCW leaving doffing areas

Discussion and Future Directions

Due to the descriptive nature of this study, the research team provides a broad analysis rather than one in-depth. Over the course of observing the simulation scenarios, analyzing the observational data and reviewing the literature, the W21C Human Factors team identified other problems for discussion and possible further evaluation.

PPE Selection

The simulation scenarios did not provide the opportunity to observe all the types of PPE that are available to AHS staff. Recommendations about which specific type of PPE is appropriate for a given context requires more detailed analysis. Consideration should be given to:

- **IPC Standards** to ensure the selected PPE meets requirements for HCW protection
- **HCW Tasks** determined through task analysis for various types of care provided

- **Anthropometric Accommodation** to assess PPE effect on range of motion and dexterity
- **Heat Strain** to define Wet Bulb Globe Temperatures for types of PPE
- **Complexity of Donning/Doffing** to determine the steps and equipment needed to don and doff each type of PPE
- **Availability** to ensure supply chain management processes can meet PPE need

Environmental Services and Support Staff

The evaluation specifically focused on HCW involved with the triage, treatment and transport of the patient. However, other AHS staff were engaged in the simulation scenario and were required to interact with the patient or contaminated materials. These individuals were therefore potentially at risk of becoming contaminated with EV. Further evaluation should assess this risk for Environmental Services and Protection Services.

Conclusion

This evaluation identified system factors associated with potential EV transmission events involving HCW, primarily during donning and doffing. Multiple simulated EVD patient scenarios involving triage, treatment and transport were observed to identify these potential transmission events. Recommendations are provided, which are intended to address system factors related to the potential transmission of EV to HCW. The recommendations themselves vary in their degree of specificity, and implementing change will require the commitment of organizational resources and consideration on an individual basis.

1 Introduction

1.1 Ebola Virus Disease Background

Transmission of the Ebola Virus (EV) to Health Care Workers (HCW) has been well documented. It is generally accepted that all body fluids should be considered as carrying live virus. EV may be carried in blood, breast milk, saliva, semen, stool, tears and urine,[1] and can be excreted for seven to fourteen days.[2,3] Blood, especially at the height of illness, has been found to have very high concentrations of the virus, with up to 6.5 log_{10} (~4 million) PFU/ml of blood.[2,4]

Evidence of EV transmission to HCW in highly resourced care settings raises further concerns about transmissibility. HCW accounted for 22% of Ebola Virus Disease (EVD) infection cases between 1976 and 2002.[5] Since March 2014, roughly 240 HCW have been infected, 120 of whom died.[6] These transmission events, despite the use of precautions, provided the impetus for one of the authors (JC) to carry out a critical review of all reports of HCW becoming contaminated with EV. The review covered the years between 1976-2014, with full text retrieval, and evaluation of quantitative and qualitative data.[7]

A summary of the quantitative data showed the vast majority of cases of EV transmission to HCW were associated with a lack of training, inadvertent contact before the diagnosis of EVD was made, and hence no use of personal protective equipment (PPE), as well as breaches of protocol during PPE use. In three well-studied settings in Africa, keys to reducing EV transmission to HCW workers included: early recognition of EVD, training, limiting the number of HCW providing care, use of the 'buddy' system, adherence to protocol precision and execution, and active removal of all 'stressed' HCW.[8] A summary of qualitative data revealed that, despite statements from index HCW reporting full PPE use, multiple and varied breaches of protocols occurred. Similarly, evaluations of PPE usage in laboratory settings have documented HCW misattributing self-contamination during doffing to contamination acquired during patient-care.[9] Examples of transmission events from the qualitative data indicated the following attribution occurrences: mucous membrane exposures, eye scratching, doffing errors, sharps injuries, answering cell phones and cleaning without full PPE.[7]

Alberta Health Services (AHS) Infection Prevention & Control considered it important to be able to respond to a suspected or confirmed case of EVD. Although there are both qualitative and quantitative data describing EV transmission to HCW, there is little to no evidence of Human Factors evaluation examining systemic factors contributing to such transmission. As a result, AHS IPC contracted the W21C Human Factors team to conduct an evaluation of the use of PPE within simulated EVD patient scenarios involving triage, treatment and transport.

1.2 W21C Research and Innovation Centre

The W21C (www.w21c.org) is a health systems research and innovation initiative based in the University of Calgary's O'Brien Institute for Public Health and the Calgary Zone of AHS. W21C's interdisciplinary team addresses health care needs through evidence-based practice, technology testing, and education outreach, informing change in the health care system to enhance patient safety and quality of care.

1.3 Human Factors

Human Factors (HF) is a body of knowledge about human characteristics (e.g., psychology and physiology) and the influence of those characteristics on an individual's interaction with other people, equipment and environments. HF knowledge can be applied in the evaluation of a system to give an understanding of how system factors contribute to facilitating or impeding human performance. In this project, HF knowledge was applied in the evaluation of simulated EVD patient scenarios to identify system factors relevant to potential EV transmission to HCW.

The object of this HF evaluation was to focus on the underlying system factors that influence HCW actions in simulated care scenarios, rather than focusing on the HCW as an individual. The findings identified and subsequent recommendations should be interpreted with respect to their relationship to the pre-defined structures and processes of care imposed on the simulation participants.

1.4 Collaboration with EVD Patient Simulation Team

The W21C Human Factors team observed a series of simulated EVD patient scenarios that were part of the AHS response to Ebola preparation. W21C's participation in this initiative enabled the Human Factors team to collect the data that form the basis of this report. The following AHS staff organized these simulation scenarios:

- eSIM – Cherie Serieska
- Emergency Disaster Management – Tom Watts
- Emergency Medical Services Patient Care Simulation – Brent Thorkelson

Additional support in organizing the simulation scenarios was provided by staff at participating tertiary acute care sites in Calgary. These include the AHS Critical Care Line Triage Centre, Critical Care, Emergency, Emergency Medical Services, Environmental Public Health, Environmental Services, Infectious Disease, Infection Prevention and Control, Laboratory Services, Medical Officer of Health, Protective Services, and Workplace Health and Safety.

Simulation organizers invited HCW and AHS staff to participate in the simulation scenarios when their department was involved, including:

- Calgary Laboratory Services Technologists
- Critical Care Medicine Physicians
- Diagnostic Imaging Staff
- Emergency Disaster Management (EDM) Staff
- Emergency Medical Service (EMS) Providers, Supervisors and Dispatch
- Emergency Medicine Physicians
- Environmental Public Health Staff
- Environmental Services Staff
- Infectious Disease Physicians
- Infection Prevention and Control (IPC) Professionals
- Medical Officer of Health (MOH)
- Referral, Access, Advice, Placement, Information, and Destination (RAAPID)
- Registered Nurses (RN)
- Respiratory Therapists (RRT)
- Portering Staff
- Protective Services Staff
- Site Administration
- Workplace Health and Safety (WHS) Professionals
- Other staff as appropriate

1.5 Ethical Consideration

In compliance with the University of Calgary's Conjoint Health Research Ethics Board (CHREB) standards for research involving human participants, this project was evaluated to determine if CHREB approval was required. Alberta Innovates Health Solutions' *ARECCI Ethics Guidelines for Quality Improvement and Evaluation Projects* were used to assess the proposed scope of work. The results of this assessment were submitted to the CHREB, and the project's exemption from ethics review was supported on the grounds that the project met the criteria for quality assurance/program evaluation activity. All photographs in this report have been digitally altered to anonymize the identity of simulation participants.

2 Methodology

2.1 Simulation Scenarios

All EVD patient simulation scenarios involved one or more standardized patients who presented at home or at one of four acute care sites in Calgary. The standardized patients approached the participating HCW and gave a history indicating a high probability of having EVD based on AHS' clinical assessment guidelines (e.g., travel to an area with active EVD transmission, fever greater than 38.0 °C and contact with an individual strongly suspected to have EVD). In addition, all patients simulated the need for defined 'wet contact' precautions, that is, vomiting and in some cases diarrhea. Simulation coordinators managed detailed scenario descriptions, lists of participants and pre-defined simulation objectives. The Human Factors teams observed the simulation scenarios and participated in the debriefings.

2.1.1 Scenario Descriptions

The following provides a synopsis of the seven simulation scenarios.

October 27th – Care of a patient in the South Health Campus Intensive Care Unit

HCW were observed as they cared for a standardized female patient who had been admitted to the Intensive Care Unit (ICU) with suspected EVD. HCW donned and doffed their PPE in the designated environments and delivered care to the patient. In addition to the standardized patient, a human patient simulator was also used to simulate physiological conditions requiring more advanced care activities, such as resuscitation.

October 31st – Transfer of a patient from the South Health Campus Emergency Department to the Intensive Care Unit

HCW were observed in the Emergency Department (ED) and ICU triaging and admitting a male patient with suspected EVD. HCW donned and doffed in the ED and ICU, and performed affiliated triage and transport tasks, such as initiating a call to the MOH, isolating the patient in the pandemic room, and admitting the patient to the ICU.

November 21st (AM and PM) – Transporting a patient from Southwest Calgary Residence to the South Health Campus Intensive Care Unit

EMS providers were observed transporting a patient with suspected EVD from her residence in southwest Calgary to the South Health Campus (SHC) ICU. This scenario was run twice in succession.

In the first simulation scenario, EMS providers donned in the patient compartment of the ambulance. Upon arrival to SHC, EMS provider Buddies donned in the SHC ambulance bay. EMS providers and Buddies doffed in the SHC ambulance bay.

In the second simulation scenario, EMS providers donned in a tent outside the patient's home. These providers donned partially while waiting for the MOH call to be completed. Upon arrival to SHC, EMS provider Buddies donned in the SHC ambulance bay. EMS providers and Buddies doffed in the SHC ambulance bay.

November 28th – Transfer of a patient from the Peter Lougheed Centre Emergency Department to the Ambulance Bay

HCW and EMS providers were observed triaging and preparing to transport a patient with suspected EVD from the Peter Lougheed Centre ED to the SHC. HCW and EMS providers donned and doffed in the ED and ambulance bay, respectively. Activities associated with triage, isolation and admission were performed. EMS providers were engaged to transport the patient from the ED to the ambulance bay.

December 3rd – Triaging a patient within the Foothills Medical Centre Emergency Department

HCW were observed triaging a patient with suspected EVD at the Foothills Medical Centre (FMC) ED. HCW donned and doffed in the FMC ED, and performed activities associated with triage and admission to the ED.

December 9th – Transfer of a patient from the Alberta Children's Hospital Emergency Department to the Pediatric Intensive Care Unit

HCW were observed triaging a pediatric patient with suspected EVD and admitting her to the Pediatric Intensive Care Unit (PICU). HCW donned and doffed in the Alberta Children's Hospital ED, and performed activities associated with triage and admission to the PICU.

2.1.2 Medical Officer of Health

After standardized patients presented at the ED (or made a telephone call to 911 dispatch as in the November 21st simulation scenarios) a call to the MOH was initiated to determine the appropriate course of action for the suspected EVD patient. Evaluating this process was outside the scope of the report, however, some observations of donning and doffing were influenced by the time spent in discussion with the MOH.

2.1.3 Environmental Configuration

AHS staff participating in the simulation scenarios were required to respond to the suspected EVD patient without prior preparation. HCW and staff had to configure the environments necessary for donning and doffing during the simulation scenarios. This generally involved assembling the equipment necessary for donning and doffing and demarcating 'hot' and 'warm' zones with tape on the floor. Hot zones were areas requiring full PPE due to proximity to the patient or contamination. Warm zones were doffing areas in which HCW removed their PPE. Areas not labeled by tape as hot or warm zones were considered clean.

2.2 Data Collection

Data were collected from the seven simulation scenarios between October 27th and December 9th 2014. Members of the W21C Human Factors team attended the simulation scenarios and recorded participants using a combination of hand-held and fixed video cameras, and still cameras (Drift HD, Nikon 810 and Canon EOS 70D). To avoid recording actual patients, or interfering with the operation of the simulations, it was not always possible to collect comprehensive, uninterrupted video and audio recordings. The observational data collected during the simulation scenarios were transferred from the recording devices to secure servers in the W21C's Healthcare Human Factors and Simulation Laboratory (HHFSL).

In addition to audiovisual recordings of the simulation scenarios, the Human Factors team obtained copies of donning and doffing procedural aids, various types of PPE, measured the skin temperature of some HCW, and photographed equipment and environments.

2.3 Evaluation of Observations

2.3.1 Audiovisual Recordings

Audiovisual recordings were analyzed in the HHFSL at the W21C Research and Innovation Centre. Multiple video files were synchronized using Adobe Premiere Pro CS6.0.2 (*Adobe Systems Incorporated, San Jose, CA*). Synchronized video files were imported into Noldus Observer XT v.11.5 (*Noldus Information Technology, Wageningen, Netherlands*), which is software designed for systematic 'behavioural' analysis. This software allows analysts to synchronize multiple media sources and apply customized coding taxonomies to time stamp and collate events and actions. These coded events or actions can then be analyzed, based on their frequency or duration.

Human Factors research analysts, in consultation with an advisory group, developed a coding taxonomy of operationally defined events and actions (Appendix 9.1). This taxonomy was used to systematically review the recordings and condense observations into meaningful categories.[10] The primary emphasis was placed on actions and events involved with **Donning and Doffing**. However, other events and actions not directly related to donning and doffing were coded. For example, analysts coded 'high risk' and 'low risk' actions or events:

- **High risk** actions were coded when the HCW was observed directly touching (or in close proximity to) mucous membranes of the mouth and nose, the eyes (conjunctiva), or placing themselves at risk for a sharps injury of any manner.
- **Low risk** actions were coded when the HCW was observed contaminating or acquiring contamination from people, equipment, or environments (except when these actions met the high risk criteria).

The definition of high and low risk actions was informed by the advisory committee, which included IPC professionals, as well as the literature review. The definition took into account the natural biology of EV and the recognized events associated with transmission of EV and other blood-borne pathogens to HCW.

The secondary focus of the study related to events and actions associated with EV transmission during **Triage, Treatment and Transport** by EMS, ED and ICU staff. Observations and descriptive data are presented, however, this secondary tier of evaluation did not involve the creation of a detailed coding taxonomy. The recommendations were informed through observation of the simulation scenarios and participation in the semi-structured debriefings. This approach, akin to ethnographic observation, is a useful quality improvement methodology, helping researchers identify problems in health care systems and offer potential explanations.[11]

2.3.2 PPE in the HHFSL

The W21C Human Factors team was provided with the AHS approved PPE outlined in the donning procedural aids for:

- HCW with **Fluid Resistant Gown** (Appendix 9.2)
- HCW With **Coveralls** (Appendix 9.4)
- PPE **Buddy** (Appendix 9.6)
- **EMS Coveralls** (Appendix 9.8)

The research team compared the fit of the HCW **Fluid Resistant Gown** and the **EMS Coveralls** on a female and a male W21C staff member. The female (height = 1.50 m, weight = 43 kg) and male (height = 1.93 m, weight = 82 kg) had heights representative of a 5th percentile female and 95th percentile male, respectively.[12]

The research team assessed gaps in coverage, range of motion, and ability to complete the donning and doffing procedures without assistance from a 'Buddy'. Data were not systematically collected about differences in fit or coverage with different types of PPE, nor was dexterity assessed.

In addition, EDM provided the Human Factors team with a Powered Air Purifying Respirator (PAPR) for testing. The W21C Human Factors team was not able to carry out any evaluation of the PAPR, nor was it evaluated in the simulation scenarios.

2.3.3 Procedural Aid Evaluation

Copies and photographs of the various procedural aids used in the simulation scenarios were evaluated according to Human Factors and checklist design principles. [13-19] The donning and doffing aids are presented in Figure 1 and Appendices 9.2 – 9.9.

2.3.4 Measurement of Temperature

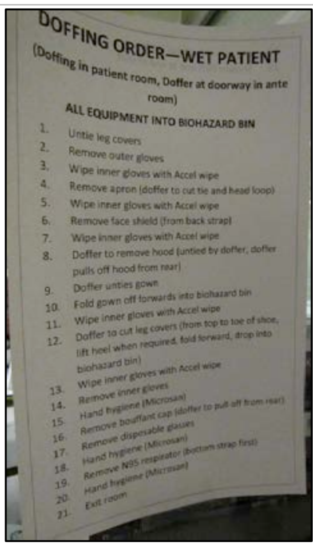
Skin temperature data were collected for a sample of twelve HCW in three simulation scenarios. HCW wore either **Fluid Resistant Gowns** (n=6) or **EMS Coveralls** (n=6). Measurements were made before donning and during or after doffing (Table 3). However, both the collection methodology and the length of time each HCW spent in full PPE to the point of final temperature measurement were highly variable. In addition, comments from HCW about being hot while wearing PPE were noted during video review (Table 4).

3 Findings

The HF evaluation was aimed at identifying factors related to potential transmission of EV to HCW. These findings were informed by 'behavioural' analysis using Noldus Observer XT (*Noldus Information Technology, Wageningen, Netherlands*). They were also informed by participation in the simulation scenarios and debriefings, consultation with subject matter experts, literature review and the team's professional judgment. This section presents findings based on observations that were deemed relevant to potential EV transmission. (Interpretation of these findings, associated system factors and recommendations are presented in Section 4).

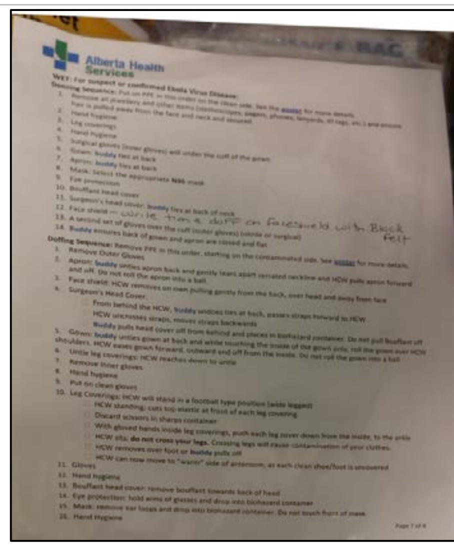
3.1 Variation in Procedural Aids

Between the October 31st and December 9th simulation scenarios, the study team observed variability in the design, content and availability of donning and doffing procedural aids (Figure 1). Five different procedural aids were observed being used. Not all the procedural aids used during the simulation scenarios were photographed or analyzed.

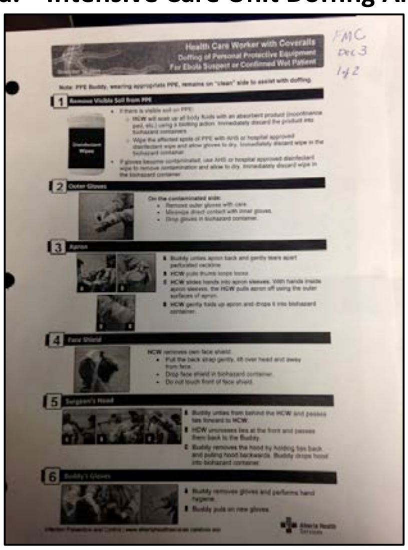


(Courtesy Susan Biesbroek, AHS)

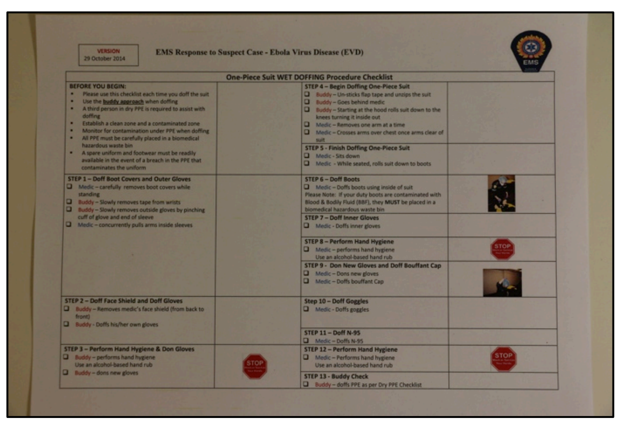
a. Intensive Care Unit Doffing Aid



b. Emergency Department Donning/Doffing Aid



c. Emergency Department Doffing Aid



d. Emergency Medical Services Doffing Aid

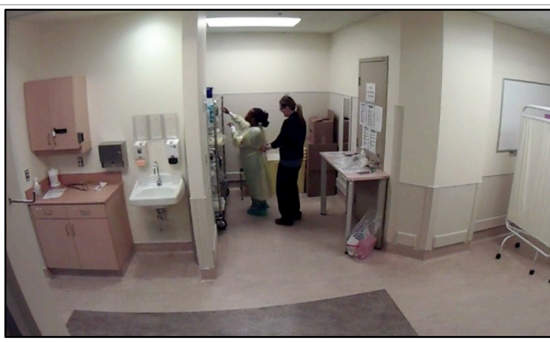
Figure 1. Variation in the design and content of donning and doffing procedural aids

3.2 Donning

There were 28 donning sequences observed, the type of PPE donned consisted of Buddy PPE (n=7), HCW Fluid Resistant Gowns (n=12) HCW Coveralls (n=3) and EMS Coveralls (n=6).

3.2.1 Donning Areas

Configuration of donning areas was observed to vary in all the simulation scenarios (Figure 2). This variation was observed between sites (e.g., receiving and non-receiving sites) and departments (e.g., ED and ICU). Differences included the actual physical size of the donning area, the proximity of the donning cart to the donning area, the workspaces available to the HCW in the donning area, and the distance from the donning area to the patient.



a. Receiving Site Donning Area

b. Non-Receiving Site ED Donning Area

c. Non-Receiving Site ED Donning Area

d. EMS Donning Area in Tent

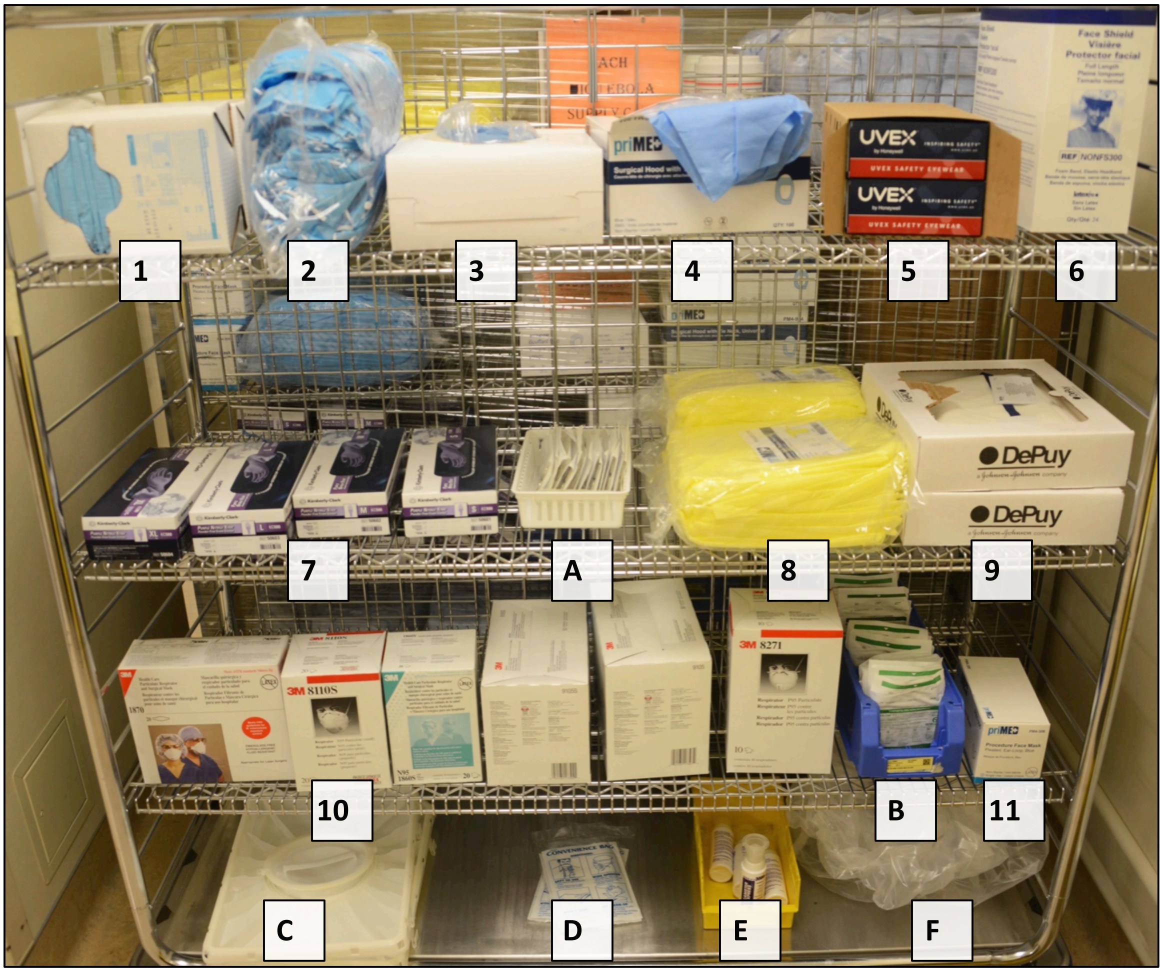
e. EMS Donning Area in Ambulance

f. Receiving Site ED Donning Area

Figure 2. Variation in the configuration of donning areas

3.2.2 Donning Carts

The layout of donning carts was observed to vary by site and department. In addition, the donning cart layout was inconsistent with donning sequences as recommended in donning procedural aids. The layout of a receiving site donning cart is described below (Figure 3).



Items for donning listed on the donning procedural aid: 1) Aprons, 2) Shoe covers, 3) Bouffant head covers, 4) Surgeon's hoods, 5) Safety eyewear, 6) Face shields, 7) Nitrile exam gloves, 8) Fluid resistant gowns, 9) Leg covers, 10) Surgical Masks and N95 masks, 11) Procedure face-masks.

Items not listed on the donning procedural aid: A) Unknown, B) Latex procedure gloves, C) Biomedical waste container lids, D) Convenience bags, E) Solidifying agent, F) Unknown.

Figure 3. Layout of donning cart observed in receiving site ICU

3.2.3 Type of PPE Donned

There were four types of 'wet-contact' PPE observed during the simulation scenarios (Figure 4) and two types of Buddy PPE (Figure 5). Some differences were observed in the design of items for the same type of PPE, such as the fluid impervious gown being yellow or blue.

a. **HCW with Fluid Resistant Gown** b. **HCW with Coveralls** c. **EMS One-Piece Suit**

Figure 4. Observed types of 'wet-contact' PPE for HCW and EMS

a. **HCW Buddy PPE** b. **EMS Buddy PPE**

Figure 5. Observed types of Buddy PPE

3.2.4 Gaps or Problems with PPE

In all of the simulation scenarios, some HCW were observed with exposed skin or scrubs, and/or fogged safety eyewear. These observations were made immediately before or during doffing. The body parts most frequently exposed were the head and neck (Table 1). Before the November 28th simulation scenario, changes were made to the donning procedure. One of these changes was to use a surgeon's hood wrapped around the neck (like a scarf) to provide additional coverage. Re-purposing the surgeon's hood to provide additional coverage for the neck was a recommendation provided by officials within AHS.

Table 1. Observed gaps in PPE coverage and visual obstruction

Observations	Count
Exposed face	10
Exposed neck	13
Exposed arms/wrists	3
Exposed back	1
Obscured visual field or face	1
Fogged safety eyewear	4

3.2.5 Deviations from the Donning Procedure

Two HCW were observed leaving a donning area without full PPE. In the first observation, one HCW entered a receiving site ICU with neither safety eyeware nor a face shield and subsequently touched his/her face (Figure 6). The second observation was of a HCW leaving the donning area without a face shield, however he/she returned to retrieve and don the face shield before entering the hot zone.

Figure 6. HCW observed touching face with no safety eyewear and face shield

3.2.6 Donning Times

The time taken to don PPE was observed to vary during five simulation scenarios. Table 2 presents the time to don PPE grouped by PPE type. (PPE type was chosen as the grouping variable because it was the focus of study.) Variability that could affect donning times was not controlled for in the scenarios.

Table 2. Donning times by PPE type

PPE Type	n	Mean* (min)	±SD	95% CI	Range
Buddy PPE	7	3.5	2.0	1.6—5.1	2.1—7.8
HCW Fluid Resistant Gown	12	10.2	3.1	8.2—12.2	4.8—14.7
HCW Coveralls	3	8.5	2.7	1.9—15.1	6.6—11.5
EMS Coveralls	6	21.6^{+}	5.7	15.6—27.6	14.9—28.7

*Mean is based on the number of participants observed in five simulation scenarios.

$^{+}$Corrected for a 20 min delay for the MOH call

3.2.7 Donning in the HHFSL

To examine fit and the possibility of an individual being able to independently complete the donning and doffing procedures, two research associates from W21C donned the HCW **Fluid Resistant Gown** and the **EMS Coveralls** PPE (Figure 7). The boot covers and outer gloves for the **EMS coveralls** were from EDM and not exactly the same as EMS providers were observed using.

A female (height = 1.50 m) and male (height = 1.93 m) donned the **Fluid Resistant Gown** and the **EMS Coveralls**, respectively. On the shortest research associate, the **Fluid Resistant Gown** was loose and the sleeves extended beyond her fingertips (Figure 7). In addition, gaps in neck coverage were visible, despite the additional surgeon's hood. The **Coveralls**, which did not carry a size label, restricted the mobility of the tallest research associate's arms and legs.

a. 1.5 m female in Fluid Resistant Gown **b. 1.93 m male in EMS Coveralls**

Figure 7. PPE fit on 5^{th} percentile female and 95^{th} percentile male

Both research team members attempted to doff their PPE without assistance from a Buddy (contrary to the process described in the AHS doffing procedural aids). The 1.50 m female was able to complete all of the steps. However, any step outside her visual field, such as untying the surgeon's hood at the back of the neck, was associated with increased contact between her hands and exposed skin. The 1.92 m male noted that the coveralls ripped at the underarm sleeve (left arm) when he attempted to remove them unaided. He was ultimately unable to unzip the coveralls and could not complete doffing without assistance.

3.3 Specific Environment Flow and Configuration

3.3.1 Emergency Departments

Emergency department donning and doffing areas were configured after the patient presented at triage and was identified as a suspected EVD patient. The process of configuration involved demarcating donning and doffing areas with tape on the floor and assembling associated equipment. This equipment included: PPE and donning carts, biomedical waste containers and PPE compression devices, hand sanitizer and Accel Wipes, and chairs. Necessary equipment was not always within reach of the HCW. For example, as shown in Figure 8, a HCW disposed of the scissors used for cutting boot covers into the biomedical waste container as opposed to into the sharps container. The sharps container is located on the wall outside the doffing area.

Figure 8 HCW disposing of scissors into biomedical waste container

Generally, patient flow followed a pattern: triage desk → 'pandemic room' (either a bathroom, office or pandemic room) → ED isolation room → ambulance bay → Ambulance (Figure 9). Donning and doffing environmental configurations can be seen in Figure 2 and Figure 15, respectively.

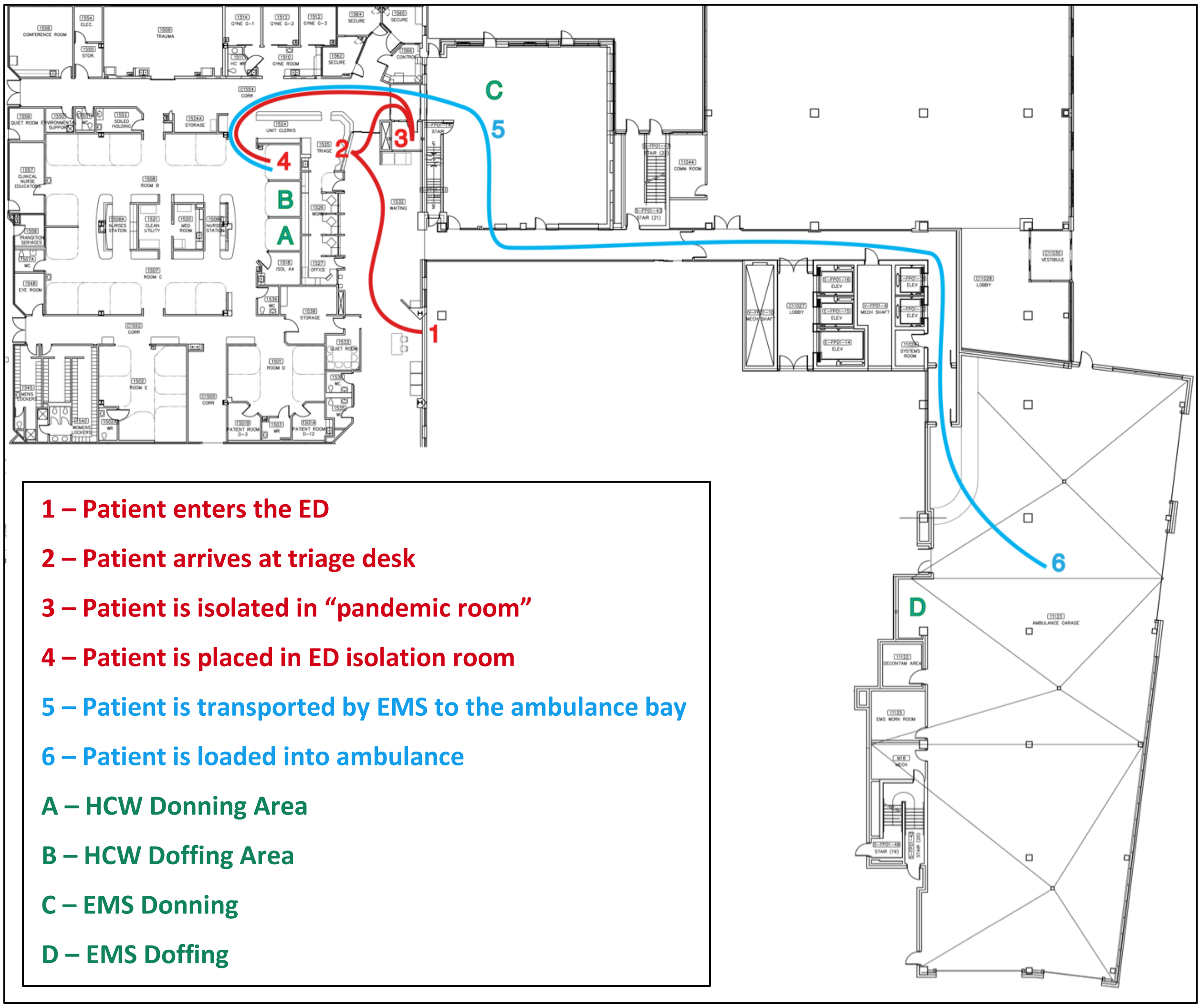


Figure 9. Non-receiving site patient flow and donning/doffing areas

3.3.2 Intensive Care Unit Flow and Configuration

One exercise involved the care of a simulated patient admitted to the ICU. The configuration of the ICU can be seen in Figure 10. In total, 110 minutes of this HCW activity in the patient room were recorded, with eight minutes involving stoppages in the simulation for reasons related to managing the simulation and patient simulator. This video footage was not analyzed using the coding taxonomy for methodological reasons, including changes made to the care environment by individuals not participating in the simulation. However, the video was still reviewed by the Human Factors team to identify potential contributors to EV transmission.

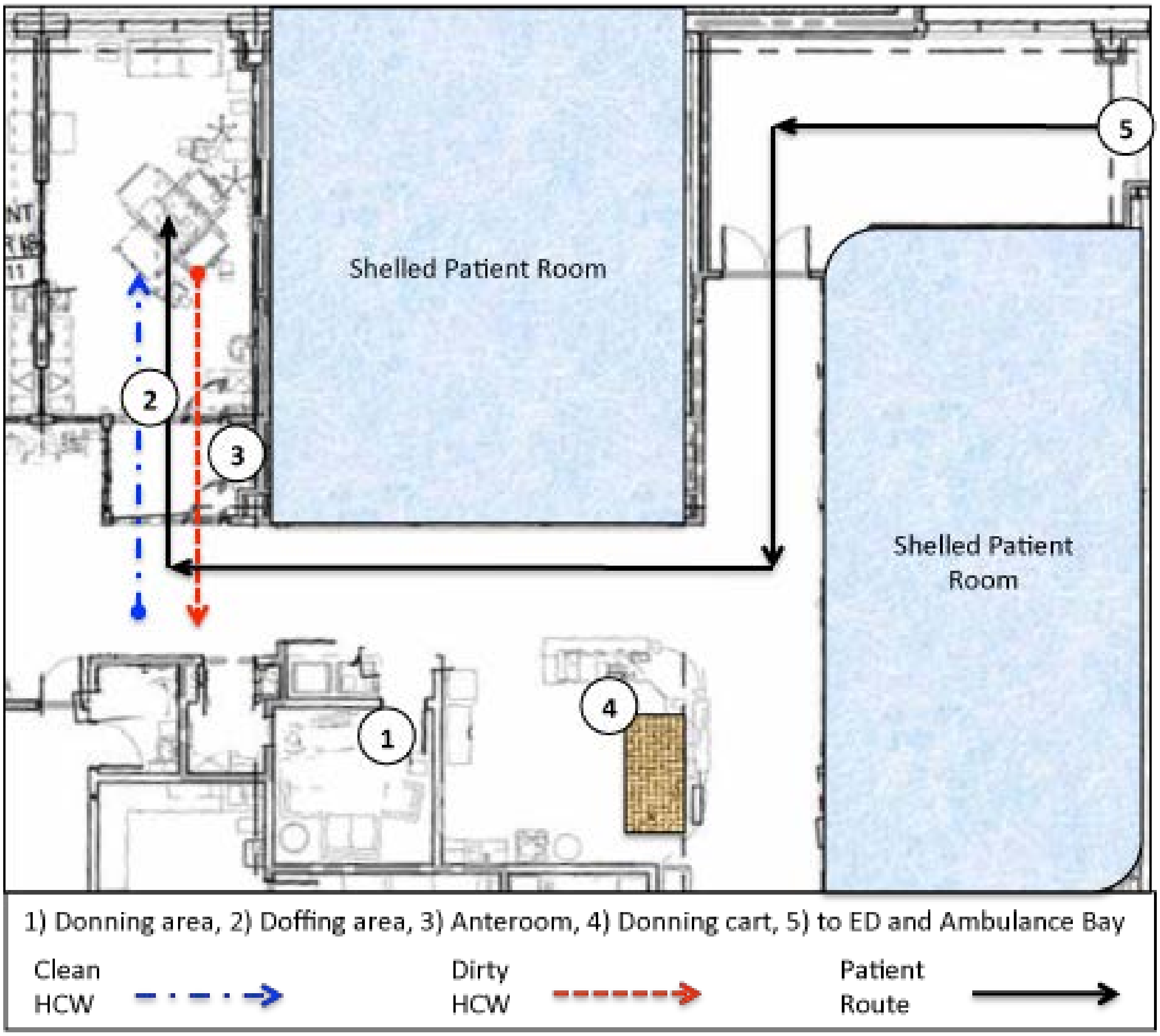


Figure 10. Receiving site ICU with flow and areas of interest labeled

In total, 15 HCW were observed entering and exiting the patient room through an anteroom and doffing in the warm zone on the patient side of the anteroom. HCW and Buddies were observed touching door handles when entering and leaving the patient room and the anteroom. Glo Germ^{TM} was added to the simulated patient's body fluids, and evidence was seen of the transfer of Glo Germ^{TM} to door handles in the anteroom (Figure 11). However, individuals managing the simulation scenario also entered and exited the patient room and the anteroom, which could have contributed to contamination of the door handle.

Doffing was carried out in front of the path into and out of the patient room. This activity obstructed entry to or exit from the patient room until doffing was completed. This obstruction also contributed to the accumulation of doffed PPE on the floor in the path of HCW (Figure 12).

a. Anteroom door handle with luminescense of Glo Germ™ **b. High risk action after touching door handle**

Figure 11. Contamination of anteroom door handle and high risk action

Figure 12. Obstruction of flow into patient room by contaminated materials, containers and people

When additional equipment was needed for care of the patient, for example, bed linens, HCW were required to move from the hot zone into the warm zone to receive the item(s) from the Buddy who was in the clean area (Figure 13). In addition, participants were observed moving from the hot zone into the warm zone to reach the workstation, including a communication device and charting equipment. Of note, HCW were observed holding the communication equipment close to the face (Figure 14) after moving between the hot and warm zones.

Figure 13. Buddy in the clean area passing materials to HCW in warm zone

Figure 14. HCW in warm zone holding communication device close to face

3.4 Doffing

There were 24 doffing sequences observed, the type of PPE doffed consisted of Buddy PPE (n=4), HCW Fluid Resistant Gown (n=12), HCW Coveralls (n=2) and EMS Coveralls (n=6).

3.4.1 Heat Stress and Heat Strain

Heat stress refers to heat-related factors that affect the body, such as the environment, clothing, metabolic heat production and acclimatization. *Heat strain* is the body's response to heat stress.[20] Skin temperatures were collected from a sample of twelve HCW wearing the **Fluid Resistant Gown** (n = 6) or **EMS Coveralls** (n = 6). Measurements were made during three simulation scenarios and were taken before donning and before, during and after doffing (Table 3). Fully audible data were available for ten HCW, of which seven made audible references indicating potential heat strain.

Table 3. Observed changes in skin temperature between donning and doffing

Fluid Resistant Gown				EMS Coveralls			
Measure	**T_i (°C)**	**T_f (°C)**	**Δ (°C)**	**Measure**	**T_i (°C)**	**T_f (°C)**	**Δ (°C)**
HCW 1	36.4	36.6*	0.2	EMS 1	35.7	36.0*	0.3
HCW 2	36.5	37.0*	0.5	EMS 2	36.8	37.4+	0.6
HCW 3	36.2	36.8*	0.6	EMS 3	35.6	36.5*	0.9
HCW	36.0	37.0+	1.0	EMS 4	35.4	36.5*	1.1
HCW 5	36.5	38.1+	1.6	EMS 5	36.8	37.9+	1.1
HCW 6	35.4	37.4+	2.0	EMS 6	35.4	36.6*	1.2
			Mean Δ (°C) = 1.0				**Mean Δ (°C) = 0.9**

T_i = Initial temperature measurement; T_f =Final temperature measurement; + = Final temperature measured before the start of doffing; * = Final temperature measured after completion of doffing.

Audio data were analyzed to identify instances of HCW expressing some indication of heat strain (Table 4).

Table 4. Verbalizations from HCW indicating potential heat strain

Verbalization
HCW: I have to warn you, my pants are wet […] Soaking wet.
HCW: Getting warm. I'm okay.
IPC: How are you feeling? **Buddy:** I'm really hot. But I can do it, he's been in longer than me.
HCW: Too hot! Phew! **Buddy:** It's hot.
Lab tech: How hot are you right now? **Buddy:** I'm pretty done.
HCW: (1) I feel like Hawaii right now.(2) I've only been in for 15 minutes, but it's warm.
HCW: I'm very hot.

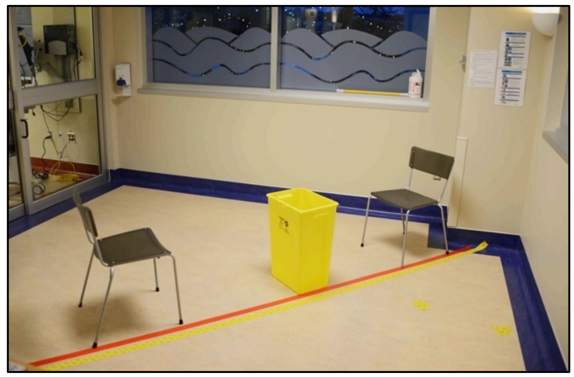
3.4.2 Doffing Areas

Doffing areas varied by location, including differences in physical space available for doffing, variation in the use of tape to demarcate hot and warm zones, and availability and placement of equipment, such as chairs and biomedical waste containers (Figure 15).

a. **Non-Receiving site ED Doffing Area**

b. **Non-Receiving Site EMS Doffing Area**

c. **Receiving Site EMS Doffing Area**



d. **Receiving Site Doffing Area**

e. **Receiving Site ICU Doffing Area**

f. **Non-Receiving Site ED Doffing Area**

Figure 15. Observed variation in the configuration of doffing areas

3.4.3 Interaction with the Buddy

There were instances observed of the Buddy and doffing HCW being out of sequence with each other during doffing (Table 5). Three simulation scenario recordings provided the audio quality necessary to determine if the Buddies and HCW were at the same step during doffing. In every observation of Buddies and HCW out of sequence, the Buddy was the individual ahead in the doffing sequence, as specified in doffing procedural aid.

Table 5. Instances of Buddies being out of sequence with doffing HCW

Step(s) ahead of the doffer	Count
1 step	18
2 steps	4
3 steps	3

3.4.4 Deviations in HCW Doffing Sequence from Doffing Procedural Aids

During doffing, the sequence of steps that HCW performed was compared to the doffing procedural aids being used. Deviations between HCW performance and the procedural aids were flagged and categorized (Table 6). Data came from the observation of six simulation scenarios and involved the use of five different procedural aids.

Table 6. Observed deviations from doffing procedural aids

Description of Deviations	Count
Step(s) followed incorrectly	
Buddy performed HCW-designated task	1
HCW performed Buddy-designated task	4
HCW did not doff PPE in IPC recommended sequence	5
HCW did not properly dispose scissors	10
Step(s) missed	
Buddy did not doff gloves as required	2
Step(s) added	
HCW doffed gloves	1
HCW or Buddy doffed gloves and put on new gloves	2
HCW or Buddy performed glove hygiene	6
HCW or Buddy performed additional hand hygiene	5
HCW and/or Buddy wiped PPE with disinfectant wipe(s)	4
Buddy wiped soles of shoes with disinfectant wipe(s)	3

3.4.5 Environmental Contamination

The configuration of doffing areas and equipment was associated with a number actions coded as low risk. For example, one HCW was observed slipping and contaminating a doorjamb while catching his/her balance. Other HCW were observed touching door handles with contaminated gloves. Table 7 describes these actions and their frequency.

Table 7. Low risk contamination from contact with the fixed physical environment

Observations	Count
HCW touched contaminated door handle with bare hand	1
HCW touched contaminated doorframe	1
HCW tracked vomitus on shoes into warm zone and/or clean area	6
HCW or Buddy moved from hot and/or warm zone to clean area with contaminated shoes	9
HCW removed boot covers and stepped on contaminated floor	6
HCW stood on contaminated coveralls then moved into clean area	10
Buddy touched door handles with contaminated gloves	4
Buddy crossed from warm to hot zone	2

3.4.6 Equipment Contamination

HCW were observed contacting contaminated doffed PPE and other associated equipment (i.e., equipment used by HCW during doffing) during doffing (Table 8).

Table 8. Low risk contamination from touching contaminated doffed PPE or associated equipment

Observations	Count
Contaminated doffed PPE	
Buddy contaminated new gloves for HCW	9
HCW and/or Buddy touched doffed PPE	19
Buddy touched vomitus-soaked boot covers	1
Contaminated associated equipment	
HCW and Buddy used same hand sanitizer	22
HCW and/or Buddy dropped and reused Accel wipes	3

3.4.7 Low Risk Contamination Involving the Doffing Procedure

Observations of low risk actions occurred specifically in relation to the doffing process (Table 9). Two categories of contamination involving doffing were observed. The first was contact indicated by the doffing procedural aid' and were coded when HCW or Buddies contaminated themselves or each other during the execution of a step as listed on the procedural aid in use. This contamination involved surfaces assumed to be dirty coming into contact with surfaces assumed to be clean, but does not indicate EV transmission to the skin or scrubs of the HCW or buddy. 'Accidental contact' was coded when contamination occurred during doffing, not in relation to following a step in the procedural aid.

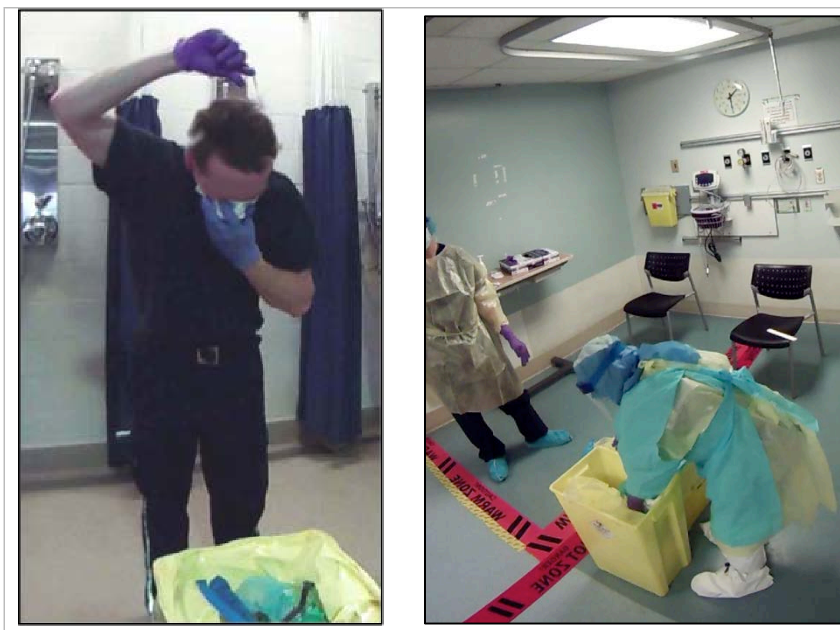
Table 9. Observations of low risk contamination during doffing

Observations	Count
Contact indicated by the doffing procedural aid	
Self-contamination	95
Contamination between HCW and Buddy	137
Accidental contact	
Buddy needed to provide additional help to HCW	2
Buddy provided balance to HCW while HCW removed boot coverings	2
HCW crossed arms while wearing contaminated gloves	1
HCW or Buddy moved their mask	4

3.4.8 High Risk Contamination

Several instances were observed of HCW performing 'high risk' actions. High risk actions were defined in collaboration with IPC professionals, and coded when the HCW directly touched (or came close to touching) mucous membranes of the mouth and nose, the eyes (conjunctiva), or placed themselves at risk for a sharps injury of any manner.

In total, there were six observations of HCW touching their facial mucous membranes or eyes with potentially contaminated body parts (hand or forearm). For example, one HCW touched his/her eyes while removing an N95 mask (Figure 16a). There were eight observations of HCW reaching into a biomedical waste container (to compress or move PPE) that contained the scissors used to cut the boot covers during PPE removal (Figure 16b).



a. Touching eyes **b. Compressing PPE in container with sharps**

Figure 16. Observed high risk contamination

3.4.9 PPE Breaches During Doffing

Breaches in PPE were observed during review of the doffing process. These breaches occurred in gloves, coverall sleeves and boot covers (Table 10). Of all the breaches, the cause of breach could be only determined in the case of ripped **EMS Coverall** sleeves, which was a result of the removal of duct tape (Figure 17a).

Table 10. Observed breaches in PPE during or immediately before doffing

Observations	Count
Ripped glove	1
Holes in EMS coverall sleeves	7
Holes in boot covers	5

a. Torn EMS coveralls **b. High risk contamination**

Figure 17. Torn EMS coveralls and consequent high risk contamination

3.4.10 Slips and Falls

HCW were observed losing their balance and/or slipping during doffing (Table 11). Loss of balance typically occurred as HCW removed shoe and leg covers. For example, an EMS provider lost his/her balance as he/she moved to sit down during doffing. A Buddy was observed slipping on vomitus that had been tracked into a doffing area.

Table 11. Observations of slips and falls

Observations	Count
HCW lost balance when removing shoe/leg covers	4
HCW lost balance when going to sit	1
Buddy slipped on vomitus	1

3.4.11 Doffing Times

The time taken to doff PPE was observed to vary across scenarios and is grouped according to the type of PPE (Table 12). This variability was not directly attributed to any factors (e.g., PPE type, configuration of the doffing area) related to doffing.

Table 12. Doffing times by PPE type

PPE Type	n	Mean* (min)	±SD	95% CI	Range
Buddy PPE	7	2.8	1.1	1.7—3.9	1.7—4.1
Fluid Resistant Gown	12	8.2	2.9	6.4—10.0	4.3—15.4
HCW Coveralls	2	8.4	0.5	4.1—12.7	8.1—8.7
EMS Coveralls	6	10.9	5.0	5.6—16.2	4.1—16.8

*Mean is based on the number of participants observed in six simulation scenarios

3.4.12 PPE Disposal

There were observations of PPE being improperly disposed of during doffing in all simulation scenarios. Table 13 summarizes the number of observed instances, with improper disposal defined as PPE on the floor or partially out of the biomedical waste container (18 gallon size). Appropriate disposal was defined as PPE being completely inside the biomedical waste container. There were 326 items of disposed PPE coded during doffing, with 179 items (54% of total items) disposed of improperly.

In addition to improper PPE disposal, HCW were observed compressing PPE into biomedical waste containers, either with their hands or an unidentified piece of equipment (Figure 18).

Table 13. Observations of proper and improper PPE disposal

PPE disposal	Count
PPE completely in biomedical waste container	165
PPE on floor	14
PPE partially out of or overflowing from biomedical waste container	147
Total	**326**

Figure 18. HCW compressing PPE in biomedical waste containers with equipment

4 Analysis and Recommendations

4.1 Simulation and Quality Improvement

This study involved the observation of *in situ* simulation scenarios, a technique blending simulated and real components of a work system.[21] Given this study required the observation of a large number of individuals responding to a 'low-probability high-severity' event simulation was both necessary and appropriate. The use of simulation as a tool for improvement in healthcare is no longer novel and can play a role in quality and safety improvements in a healthcare organization.[21,22] Thus, although an observational study design does not allow causal inferences to be made, the methodology used in this study still provides results that can be used for informing recommendations for system improvement.

Duchscherer and Davies[23] reference two frameworks that can be applied when developing and writing recommendations for system improvements. The 'Hierarchy of Effectiveness' (Figure 19) describes 'low-level' recommendations targeting people as less effective than 'high-level' recommendations targeting equipment and environmental parts of the health care system.[24]

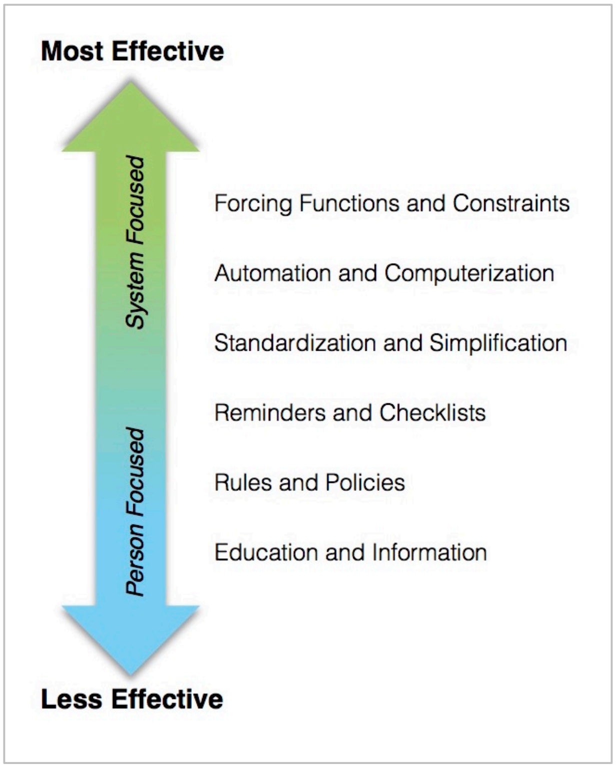


Figure 19. Hierarchy of effectiveness for recommendations targeted at people and systems

The S.M.A.R.T criteria[25] can be used to help design recommendations for effective implementation. Recommendations should be: **Specific**, clear and focused on specific improvement; **Measurable,** the implementation is quantifiable by the organization; **Assignable,** can be delegated to a specific individual; **Realistic,** feasible within the specific context of the organization; and **Timely,** implementable within a reasonable timeline.

The Hierarchy of Effectiveness emphasizes that training is only one of many approaches to promote system change. The S.M.A.R.T. framework may be a useful tool if the organization makes a decision to implement a recommendation, in order to ensure that implementation is likely to succeed. The following recommendations exist along a continuum of these frameworks and their implementation will require evaluation on an individual basis. These recommendations are grouped according to their associated system factors and are prefaced with a description of relevant findings and the analysis by the Human Factors team.

4.2 Policies and Procedures

4.2.1 Procedural Aids

Relevant Findings: Deviations between the HCW donning/doffing sequence and the sequence recommended by procedural aids, out of sequence doffing, inconsistencies in procedural aid design relative to design guidelines and variation in procedural aid design were all observed. All HCW relied on the procedural aids during the donning and doffing processes. However, the majority of HCW (with the exception of EMS providers) did not follow either a Challenge-Respond (CR) or Call-Do-Respond (CDR) method while using the procedural aids. The pattern of behaviour was therefore generally not consistent with the recommended use of a checklist.

Analysis: A procedural aid, or protocol, provides step-by-step instructions to help the user complete a task and appropriately follow a sequence of actions.[17,18] In contrast, a checklist is a standardized list of criteria systematically arranged to allow checklist users to determine the presence or absence of those criteria.[16] There are two types of checklists, CR and CDR.

In CR checklists, an individual completes a sequence of actions. After completion of the sequence, a partner reads off the list of checklist criteria (CHALLENGE) and the other partner confirms whether those criteria have been met (RESPONSE). CR checklists ensure only that criteria are met, not their sequence.[14]

In CDR checklists, one partner reads out an action from the checklist (CALL) that is to be performed; the other partner performs the action (DO), and then announces the completion of the action (RESPOND). CDR checklists are more cognitively demanding, but ensure critical actions are performed in the desired sequence.

The observations from the simulation scenarios, in combination with a review of the literature on checklist design, suggest that checklists could be used during donning and doffing. Adhering to the principles of checklist design and usage could help decrease the variation observed in donning and doffing performance.

Recommendations for Checklist Design:

- Design donning and doffing checklists to be used with a CR or CDR method
  - CR is suitable for donning because critical criteria (e.g., no exposed skin, appropriate equipment selected) can be assessed at the end of the process. Risk from missing steps or performing steps out of order can be managed after the individual has completed the donning process.
  - CDR is suitable for doffing because critical criteria must be performed in a specified sequence. Missing a step or switching steps in the middle of the doffing process would contribute to significant risk.
- Design donning and doffing checklists to be consistent with checklist design guidelines.[13,15,19]
- Use checklists as cognitive aids, not instructional materials.
- Standardize checklists within the organization.
  - Document, date and disseminate all modifications.
  - Avoid ambiguity between versions of checklists.
- Design checklists with the assumption that they will be viewed both in print and digitally.
- Ensure consistency between checklist terminology and real world references.
  - Ensure every term used in the checklist matches the label used on the packages of the corresponding item of PPE.
- Ensure consistent terminology within and between every checklist and procedural aid.
  - Avoid the use of different terms for the same item (e.g., Fluid Impervious Gown and Fluid Resistant Gown).
- Design separate checklists for separate clusters of related tasks (e.g., donning, evaluating the results of donning).
- Develop checklist content through observation of the environment and formal task analysis.
  - Have checklist steps follow a logical sequence based on the priorities of the user.
- Ensure checklists undergo Human Factors usability testing and iterative design.
- Use checklists to supplement other interventions, including equipment redesign and education.[26]

4.2.2 Doffing Procedure

Relevant Findings: The current doffing procedure itself dictates a high frequency of contact between HCW and Buddies, as evidence by the instances of low risk HCW contamination while doffing. In contrast, the Médecins Sans Frontières (MSF) doffing process involves a more independent doffing style.[27] However, doffing independently, as observed in the HHFSL, was found to be difficult and associated with a high degree of contact with exposed skin around the neck.

Analysis: The current doffing procedure is associated with a high degree of physical contact between HCW and Buddies. However, optimizing the process to minimize physical contact cannot be done without considering other relevant system factors (e.g., checklists, PPE design, associated equipment, training and role familiarity, etc.). Optimizing system factors associated with doffing will help ensure minimal contact between HCW and minimal self-contamination of HCW.

Recommendations:

- Design the doffing process to minimize contact between the Buddy and HCW, and between HCW hands and their own scrubs and skin.
- Provide equipment to help Buddies and HCW monitor physical contact (e.g., mirrors in doffing areas).

4.2.3 Roles and Responsibilities

Relevant Findings: The roles observed relevant to donning and doffing were: 1) HCW, 2) Buddy, and 3) IPC Monitor. Multiple individuals were observed donning at the same time and the individual overseeing donning and doffing was typically another HCW. The Buddy overseeing donning and doffing appeared reliant on the procedural aid. Despite this apparent reliance procedural deviations did occur.

Analysis: Although co-monitoring behaviour was observed, as shown in Table 4, the primary role of the Buddy appeared to be facilitating donning and doffing. However, other health organizations, including MSF, the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO), have recommended a more expanded role for the Buddy. The role generally involves accompanying the HCW into the hot zone and co-monitoring for signs of stress and risky behaviours. [27-30]

In addition, the CDC recommends assigning an onsite manager.[31] However, the role of the onsite manager did not appear to be clearly assigned or defined in the simulation scenarios. The CDC also recommends that a trained observer watch all donning and doffing procedures to ensure HCW adhere to best practices.[31] What constitutes a 'trained' observer is not clear, however the role would presumably entail a high-degree of familiarity with donning and doffing. In addition, observing multiple individuals don or doff at the same time increases cognitive demand on the observer.

Recommendations: Roles and associated responsibilities for each individual involved with the management of the EVD patient should be clearly defined and readily accessible. The following recommendations relate to the responsibilities of HCW specific to donning and doffing, and potential EVD contamination associated with habitual behaviours and heat strain.

- **Health Care Worker**
    - Demonstrate competency for donning and doffing before treating EVD patients
    - Self-monitor for signs of heat-strain while wearing PPE
        - Ensure pre-hydration and take time to cool down when necessary
        - Monitor breathing and heart rate
- **Buddy**
    - Co-monitor self and the HCW for potential EVD contamination and symptoms of heat strain
    - Warn HCW of potential risky actions (e.g., touching face)
- **IPC Monitor**
    - Lead training in PPE processes
    - Document training programs, proficiency and competency of HCW, including determining which HCW are sufficiently trained
    - Designate appropriate areas for donning and doffing
    - Aid HCW in selecting properly fitted PPE
    - Oversee the donning and doffing of each individual
    - Determine which HCW can be sufficiently protected by the available PPE
    - Manage the number of individuals donning or doffing at a single time
- **Onsite Manager**[31]
    - Ensure donning and doffing areas are appropriately configured
    - Oversee the implementation of precautions for HCW and patient safety
    - Ensure the safe and effective delivery of EVD treatment, within the scope of practice of the onsite manager
    - Determine HCW familiarity with IPC standards
    - Monitor supplies
    - Monitor care before, during and after staff enter an isolation or treatment area
- **All Team Members**
    - Avoid multi-tasking during donning or doffing
    - Be aware of other team members' roles and responsibilities
    - Alert other team members to habitual behaviours
    - Ask individuals wearing PPE if they are experiencing heat strain
    - Ensure individuals familiar with the doffing procedure to oversee the process
    - Identify possible EVD contamination and initiate appropriate decontamination

4.2.4 Training

Relevant Findings: Current IPC and WHS training processes were not analyzed in this study. However, HCW and Buddies were observed relying on the procedural aids to guide them through the donning and doffing process. Deviations from these aids and contamination associated with these processes were observed. In addition, actions were observed that could contribute to EV transmission, including 'habitual' behaviours.

Analysis: Habitual behaviours include the actions that people do on a daily basis and without conscious thought, such as nose rubbing or beard stroking. People also carry out automatic actions in response to a stimulus, such as wiping sweat away from the forehead. In healthcare, these habitual behaviours can include actions that are well practiced, such as placing scissors into the closest disposal container. Habitual behaviours can contribute to errors being made[32] and could result in contamination. However, despite the well-learned and automatic nature of habitual behaviours, they can be modified.[33]

One interpretation of the variation in donning and doffing performance and the observed instances of HCW contaminations relate to the current training of HCW and Buddies. Without evaluating existing training programs, specific gaps cannot be identified, however, the following recommendations relate to developing training programs for IPC generally.

Recommendations:

- Conduct a **Training Needs Analysis**[34] to determine:
    - **Trainees** – the characteristics of the population to be trained
    - **Trainers and Methods** – the resources available for training
    - **Content** – the primary objectives of training
- Align the **Training Methodology** appropriately with the goals of the training program
    - Use **lecture- or text-based** methods for training simple learning objectives, such as rote memorization sequence, not techniques.[35]
    - Use **video- and web-based** methods to encourage compliance with recommended procedures,[36] assess gaps in trainee population knowledge,[37] or to train procedural skills.[38]
    - Provide **hands-on training and physical simulation** to support the development of muscle memory and procedural competency.[39,40]
        - Use simulation-based training to avoid placing HCW and patients at risk with the traditional 'See one, do one, teach one' method.[41]
- Develop training strategies around four principles:[42]
    - *"Present relevant information or concepts to be learned."*
    - *"Demonstrate the knowledge, skills and actions to be learned."*
    - *"Create opportunities for trainees to practice the skills."*
    - *"Provide feedback to trainees during and after their practice."*
- Train specifically for knowledge and skills relating to:
    - **Self-Awareness** of habitual behaviours and the importance of minimizing them.
    - **Hazard identification**, awareness of where contamination may occur and knowledge of how to respond appropriately should contamination occur.

- **Familiarity with PPE,** specifically how it will affect HCW mobility and dexterity, as well as how their body reacts to heat stress.
- **Procedural Competency**, repetitive training including appropriate technique for the motions associated with doffing PPE and checklist use.
- **Buddy roles** that support HCW including the management of PPE breaches, minimizing the spread of contamination, and avoiding high risk behaviours.

4.3 Equipment

4.3.1 Personal Protective Equipment

Relevant Findings: HCW were observed with gaps in coverage from their PPE or breaches in their PPE. In addition, some HCW expressed experiencing heat strain while wearing PPE and some HCW were seen bringing communication equipment close to their face. W21C researchers who tried on different types of PPE in the HHFSL found the sizing of available PPE did not fit the 5th percentile female or the 95th percentile male.

Analysis: Factors contributing to gaps or breaches in PPE include the PPE available, HCW characteristics and doffing procedures. Heat stress related to PPE may add to other factors that already contribute to HCW heat strain. In addition, difficulty communicating while wearing PPE can partially be attributed to the impairment of sensory perception from the PPE.

Recommendations:

- Provide PPE that is appropriately sized for the HCW population.[43]
  - Consider the range of HCW, including the dimensions of the 5th percentile of the female workforce and 95th percentile of the male workforce.
  - Determine the physical characteristics of the specific population of HCW who wear PPE. (Although anthropometric data are freely available, they are often biased towards specific populations, such as military personnel.)
- Address gaps in coverage by providing appropriately designed PPE.
  - Avoid gaps in neck coverage. Using an additional surgeon's hood is a positive change. However, PPE that is specifically designed to cover the neck should be provided as opposed to 'jury-rigged' solutions.
- Avoid the use of adhesives that tear PPE or select PPE that does not require adhesives to provide HCW with full protection.
- Provide anti-fogging solutions and hands-free communication devices to manage sensory impairment associated with wearing PPE
- Refer to existing recommendations for HCW to manage heat strain associated with wearing PPE are in place within AHS (Appendix 9.10).
- Have HCW familiarize themselves with the symptoms of heat strain and self-monitoring.

- Provide support and back-up so that HCW can doff promptly.
- Mark PPE with a label identifying the HCW (name and role) as well as the time of donning.
    - Ensure this labeling is clearly visible to both the HCW and the Buddy.

4.3.2 Donning Carts

Relevant Findings: The layout of donning carts was observed to vary between locations. The content was organized inconsistently with the flow of the procedural aid (Table 14 and Figure 3). In addition, not all items on the cart were necessary for the donning process.

Analysis: The lack of standardization and mismatch with donning procedural aid could contribute to increases in donning time and the probability that the sequence of donning would be incorrect.

Table 14. Comparison of receiving site donning cart layout and recommended donning sequence

Fluid Resistant Gown Stocking *Top to bottom, left to right*	**Fluid Resistant Gown Donning Procedure**
1. Aprons	1. Leg covers
2. Shoe covers	2. Inner gloves (surgical)
3. Bouffant head covers	3. Fluid impervious/resistant gown
4. Surgical hoods	4. Apron
5. Safety eyewear	5. Mask or N95 respirator
6. Face shields	6. Eye protection
7. Nitrile exam gloves	7. Bouffant head cover
8. Fluid resistant gowns	8. Surgeon's hood (head and neck)
9. Leg covers	9. Face shield
10. N95 masks	10. Outer gloves
11. Procedure face masks	

Recommendations:

- **Restrict** donning carts to donning items included on the donning procedural aid.
- **Organize** donning supplies following the sequence in which each is put on by a HCW according to the donning procedural aid. Specifically the sequence should flow from left to right and from top to bottom.
- **Label** each item's location on the cart with the name from the donning list.
- **Colour-code** items logically
    - Colour-code items for the **Coverall** sequence in 'yellow' and items for the **Fluid Impervious Gown** sequence in 'blue'.
- Cluster and label doffing associated equipment if carts must be used for holding both donning and doffing equipment.
    - Consider storing doffing equipment with clean biomedical waste containers.

4.3.3 Equipment Disposal

Relevant Findings: Observation of the disposal of PPE (326 items) revealed that almost half the items (by piece not volume) were disposed of incorrectly. In addition, improper disposal of sharps contributed to high risk actions, (i.e., compression of PPE in a biomedical waste containers containing scissors).

Analysis: The biomedical waste containers (18 gallon size) available were not sufficient in size or quantity to contain all the disposed PPE. Reasons for incorrect sharps disposal could include the sharps containers in the doffing area being out of reach of the HCW, as well as ambiguity in the instructions provided about recommended scissors disposal.

Recommendations for Biomedical Waste Containers:

- Consider following the CDC criteria when selecting biomedical waste containers for sharps[44] and PPE disposal.
- Select biomedical waste containers taking into consideration the physical space available for doffing, as well as the frequency with which full containers can be removed and empty containers can be provided.
- Select biomedical waste containers with openings that allow HCW to dispose doffed PPE without contacting the outside of the container.
- Determine the amount of PPE that will fill a biomedical waste container. This determination should inform calculation of the number of HCW who can doff before a container becomes filled to capacity.
    - Mark containers with their maximum volume.
- Assess risks associated with compressing PPE in biomedical waste containers.
    - Dispose of scissors (and other sharps) in sharps disposal containers.
    - Equip each container with tool appropriately designed for compression, if compression is advised.
        - Size the tool for disposal in the containers with the PPE.
        - Label tool clearly as to the handle and compression ends.
        - Use one tool for every one container.
- Design training and supportive materials to tell HCW what to do if the biomedical waste container becomes filled during doffing.
- Place sharps containers for scissors within reach of the doffing HCW in the demarcated doffing zone.

4.4 Environment

4.4.1 Emergency Departments

Relevant Findings: Donning and doffing spaces were created in ED after the arrival and triage of the suspected EVD patient. Creating these spaces involved the collection of necessary equipment, as well as demarcation of hot and warm zones in hallways and spaces adjacent to patient isolation or assessment areas. Initial isolation areas included ‘pandemic rooms’, bathrooms and office spaces.

Analysis: Spaces not specifically designed for managing patients with highly contagious infectious disease, such as EVD, will have to be modified on a case-by-case basis when the need arises. In some cases the physical characteristics of the space may restrict HCW range of motion, for example when hallways were used for donning, or when doffing areas were established at doorways. Additionally, when donning or doffing are carried out in ED hallways, the flow of patients, personnel and materials can be affected.

Spaces used to isolate a patient in the ED can also influence HCW-patient interaction. For example, isolating a patient in a bathroom may seem appropriate because of the patient’s need for a toilet. However, the absence of audiovisual communication devices can impair the HCW ability to monitor the patient. In addition, using a space that has only one entrance and exit limits accessibility. It may be difficult to transport a patient into the room on a wheelchair or bed, and may lead to high risk actions, such as having patients or HCW walk through vomitus.

Recommendations:

- Equip patient isolation rooms with equipment or services (e.g., toilets, fluids, cellular reception) that ease suspected EVD patient wait times.
- Ensure spaces allow HCW to move to a 4 m distance from the patient without occluding a point of exit, should HCW PPE be breached.
- Equip patient holding areas with two-way audiovisual communication between individuals in the room and those outside.
    - Test the communication system to ensure compatibility while wearing PPE.
- Standardize the location and setup of these spaces within the ED.

4.4.2 Intensive Care Unit Patient Rooms

Relevant Findings: The ICU patient room observed had a single point of entry and exit through an anteroom. A doffing area was created in the doorway between the anteroom and patient room. The doffing area was at the recommended 2 m from the patient’s bed. HCW were observed moving from the hot zone to the warm zone to receive equipment passed from the anteroom inwards, as well as moving to a workstation and accessing communication devices. Contamination was observed on door handles in the anteroom. Multiple HCW were observed entering and exiting the patient room. Contamination potentially spread out of the hot zone into the clean side of the anteroom.

Analysis: The design of this environment obstructed the flow of HCW and material into the patient room when one HCW was doffing. In addition, having a doffing area directly adjacent to a high traffic area, specifically the only doorway, could have contributed to the spread of contamination between rooms. Contamination spreading from the doffing area into the anteroom was possibly a result of the doffing Buddy acquiring contamination from the HCW during the doffing process and then touching the anteroom door handles.

Recommendations:

- Use physical barriers to separate hot and warm zones, and clean areas.
- Maintain the clean in/dirty out flow by having separate entrances and exits.
- Design HCW workspace to minimize the movement of HCW between hot and warm zones.
- Demarcate HCW workstations within patient rooms as part of hot zones.
- Frequently decontaminate high contact surfaces, such as door handles, hand-held communication devices and IV pumps.
- Ensure doffing areas are not placed in high traffic areas where contamination could accumulate in the environment and on equipment.

4.4.3 General Environmental Considerations

Relevant Findings: Some low risk actions, including contamination from equipment or the physical environment, were potential contributors to HCW EV exposure. HCW were observed acquiring contamination from contact with the environment, as well as contaminating the environment through contact.

Analysis: Contamination between the HCW and the physical environment is influenced by the size of the doffing area. In addition, providing adequate physical space in donning areas to allow HCW full range of motion may enable them to test the fit and mobility provided by PPE after donning.

Recommendations:

- Design spaces to provide adequate clearance between HCW and equipment, the physical environment or other HCW.
- Ensure donning and doffing areas allow the 95th percentile male full range of motion, including full arm span, which for males between 17 and 51 years of age is 1.96 ± 0.82 m.[12]

4.4.4 Equipment for Donning and Doffing

Relevant Findings: Health care workers were observed becoming contaminated by contact with equipment in the doffing area and their own PPE. For example, HCW were observed slipping during removal of PPE. They were also observed holding contaminated communication equipment close to the face. Finally, the design and use of tape to demarcate hot and warm zones was observed to vary between each site and department.

Analysis: These observations demonstrate the potential for contamination to spread from equipment in doffing areas to and from other HCW. Contamination from the equipment associated with donning and doffing areas, and slips and falls related to the equipment or environmental design, may be managed by providing equipment that supports HCW tasks, particularly donning and doffing. Finally, there is variation in the design of equipment available for HCW donning and doffing, and variation in how it is configured to create supportive environments. Equipment design and configuration could be optimized and standardized.

Recommendations:

- Ensure hand sanitizers are available and close to HCW and Buddies during doffing.
    - Provide 'fixed' hand sanitizer containers (that are attached to a wall) are available in all designated doffing areas.
    - Provide portable hand sanitizers for impromptu doffing areas, recognizing that these sanitizers may be touched by a HCW for purposes other than sanitization of the hands, for example to move it to another location.
- Provide appropriately sized chairs with a fixed base for doffing.
- Ensure equipment intended for use by multiple HCW is adjustable.
- Place mirrors in donning and doffing areas so that HCW can observe themselves and monitor each other during donning and doffing.
- Provide hands-free communication devices in any isolated space.
- Provide easily cleaned work surfaces, such as Mayo Stands, in both donning and doffing areas.
- Ensure physical barriers are available if needed to separate clean and dirty zones.
- Standardize tape to clearly demarcate hot/warm zones and clean areas. For example, use red for hot zones and orange for warm zones.
- Ensure clean scrubs and hydration are available for HCW leaving doffing areas.

5 Discussion and Future Directions

Ideally, research involving the coding of observational data involves multiple raters coding the same observations independently ("independent dual coding") to allow for the calculation of a measure of inter-rater reliability.[45] However, due to the descriptive nature of this study, researchers provided a broad analysis rather than one in-depth. Dual coding was not carried out. Instead, two research analysts coded separate data in tandem and resolved ambiguous observations through arbitration and in discussion with subject matter experts.

The information collected in the analysis of these simulation scenarios does not allow the development of recommendations about the selection of specific types of PPE. Although type of PPE is a factor contributing to the risk of EV transmission to HCW during donning, doffing and patient care, during the study, factors relating to each type of PPE were not controlled. Not all types of PPE available in the region were evaluated.

The research team made other observations during this project that were out of the scope of analysis, but which could have an effect on the risk of HCW exposure to EV. These observations are presented for discussion and as consideration for suggested further evaluation.

5.1.1 PPE Selection

Not all types of PPE available to AHS staff were observed in the simulation scenarios, for example, PAPRs were not used. In addition, measurements relating to PPE fit and to heat strain were *ad hoc*; firm conclusions require more rigorous experimental design. The characteristics of the HCW population should be assessed with respect to anthropometric dimensions and percentage body fat, to help with sizing and appropriate purchasing. Additional research should be conducted to examine the interaction between PPE coverage, task performance and related factors. Constants for Wet Bulb Globe Temperature associated with various types of PPE could be a useful metric for comparing PPE and heat strain in a standardized fashion.

Although not all these factors were fully assessed in this study, the following could be considered when selecting PPE:

- **IPC Standards**
  - Ensuring the PPE selected meets the IPC standards for HCW protection
- **HCW tasks while donned**
  - Determined with tasks analyses for various types of care provided
- **Anthropometric Accommodation**
  - Assess PPE restriction on range of motion
  - Determine the fit of PPE to match the population of HCW
  - Describe tradeoffs between PPE protection and HCW dexterity

- **Heat Strain**
  - Determine the Wet Bulb Globe Temperatures for various types of PPE
- **Complexity of Donning/Doffing process**
  - Consider the number of items of PPE required and the complexity of their use
  - Determine the equipment required to doff, such as scissors, chairs and mirrors
- **Availability**
  - Engage the relevant supply chain management processes to ensure selected PPE is available for HCW (resource allocation during pandemics)

5.1.2 Environmental Services and Support Staff

Environmental Services staff were observed (and self-identified to the researchers) as being unfamiliar with the donning and doffing process. Similarly, Protective Services staff also admitted to being uncertain as to whether or not they needed to don PPE to manage a patient. These comments were made relating specifically to their responsibility to contain agitated patients while maintaining a distance of 2 m from the patient.

Support staff who are likely to come into contact with EVD patients or contaminated materials are a potentially at-risk population that requires further study. This study could include their roles and the requirements for the safe management of their responsibilities.

6 Conclusion

Evaluation of the simulation scenarios revealed a number of events and actions associated with potential increased risk of HCW exposure to EV. The 'Swiss Cheese' model of accidents emphasizes that accidents are "a combination of specific events and the failure of one or more of the barriers."[46] Some of Reason's barriers can be considered analogous to system factors, which could have contributed to the events and actions. The final report is intended to provide AHS IPC with a better understanding of how HCW and their interaction with specific AHS systems contribute to the potential for EV transmission.

The purpose of this evaluation was to identify system factors associated with potential EV transmission to HCW, particularly during donning and doffing. Multiple simulated EVD patient scenarios were observed involving triage, treatment and transport. Findings from the observational analysis highlight areas where transmission was possible. Analyses identified system factors related to these events. Recommendations include strategies to address the system factors through modifications to Policies and Procedures, Equipment and Environments. Implementing these recommendations will require consideration on an individual basis and the commitment of organizational resources. Although developed through the observation of simulated EVD patient scenarios, the recommendations may be applicable to other infectious diseases and potentially 'the next Ebola'.

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9 Appendices

9.1 Coding Taxonomy

Category	Code	Operational Definition
Type of PPE	EMS coveralls	Assign based on the definitions of PPE as described in AHS in procedural aids
	HCW coveralls	
	Fluid Resistant Gown	
	Buddy PPE	
	None	
Duration of sequence	Doffing	Time from when a person enters the warm zone to doff to when they step into the clean area
	Donning	Time from when HCW begins donning (first contact with materials or documentation) to when they are fully donned
Gaps or problems with PPE	PPE coverage gap	Observations of skin or scrube exposure after HCW has fully donned PPE
	PPE visual obstruction	Observations of any visual obstruction to HCW caused by PPE fit or fogging
Communication	Heat strain	Verbalizations from HCW wearing PPE in reference to feeling hot
Checklist	Deviation from checklist	Observations of deviations from doffing process recommended by procedural aides
	A step (or more) ahead of the doffer	Observations of monitor or buddy being out of sequence with doffing HCW
Breach in PPE	Breach in PPE	Observations of tears/rips in PPE during or immediately prior to doffing
Doffed PPE Disposal	PPE in overflowing biomedical waste container	Observations of any PPE disposed partially above or over a biomedical waste container's upper edge
	PPE on floor	Observations of any PPE disposed on the floor
	PPE in containers	Observations of any PPE disposed fully within the biomedical waste container
Adverse event	Slip or loss of balance	Observations of HCW or Buddies slipping and/or losing their balance
Risk assessment	High risk	Observations of HCW touching facial mucous membrane or reaching into a biomedical waste container containing the scissors used during doffing
	Low risk	Observations of any contact with persons, equipment, or the environment, that could involve EV transmission (excluding high risk)

Low risk contamination	People	Observations of HCW and Buddy contact when one individual is 'dirty' and the other is 'clean'
	Self	Observations of HCW or Buddy contacting their own 'clean' scrubs or skin with 'dirty' PPE
	Environment	Observations of HCW or Buddy touching contaminated parts of the fixed physical environment
	Equipment	Observations of HCW or Buddy touching contaminated doffed PPE or associated equipment

9.2 Health Care Worker with Fluid Resistant Gown Donning

Health Care Worker with Fluid Resistant Gown

Donning of Personal Protective Equipment For Ebola Suspect or Confirmed Wet Patient

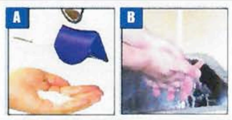
November 12, 2014

All HCWs will wear hospital supplied scrubs under the PPE, as well as clean, sturdy, fully-enclosed footwear.

1 Preparation

- Pull your hair back and secure it off your neck and face.
- Remove all extra items on your person. This includes, but is not limited to:
  - Jewellery, watches
  - ID tags, lanyards
  - Stethoscopes
  - Pagers, phone, etc.

2 Hand Hygiene



A Use an alcohol-based hand rub, the preferred way to **clean your hands.**

B If your hands look or feel dirty, soap and water **must** be used to wash your hands.

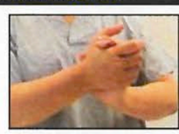
3 Leg or Shoe Covers

A Sit on a chair or stool.

B Fit the leg cover over lower leg and shoe and pull as high as it will go.

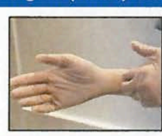
C Tie the tie around your ankle.

4 Hand Hygiene



- Use an alcohol-based hand rub, the preferred way to **clean your hands**.

5 Surgical (Inner) Gloves



Put on surgical gloves.

- They will go **under the cuffs of the apron**.

6 Fluid Impervious Gown

Make sure the gown covers from neck to knees and to wrists.

- Tie at the back of neck and waist.
  - **Buddy** may assist with ties.

7 Apron

Make sure the apron covers from neck to knees and to wrist.

- Insert your thumbs in the loops in the sleeves.
- Tie at the back of the waist.
  - **Buddy** may **assist** with ties.

Health Care Worker with Fluid Resistant Gown
Donning of Personal Protective Equipment For Ebola Suspect or Confirmed Wet Patient

November 12, 2014

8 Mask or N95 Respirator

A Surgical or Procedural Mask:

- Put ear loops over ears.
- Pinch nose piece to fit bridge of nose.

B N95 Respirator (required for aerosol generating medical procedures):

- Stretch out elastic bands, cup N95 in one hand and hold to face.
- Put top elastic on crown of head first, then put bottom elastic at base of head.
- Test for appropriate fit.

9 Eye Protection

- Place over eyes.
- Adjust to fit.

10 Bouffant Hair Cover

- Ensure all hair is covered by bouffant to prevent hair falling forward.

11 Surgeon's Hood

A Head cover

1. Put on hood.
2. **HCW** crosses ties at the front. **Buddy** adjusts the front, ensuring ties lay flat and ties at back of neck.

B Neck cover

1. **Buddy** folds a second surgeon's hood (to use as a neck cover) so the top of the hood is folded inside.
2. **Buddy** wraps the hood around front of the neck of **HCW** to cover any gaps in PPE, ensuring neck cover is flat.
3. **Buddy** ties at the back of the hood.

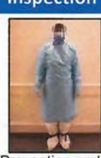
12 Face Shield

- Place the face shield over your face.
- Adjust to fit.

13 Outer Gloves

- Put a second pair of gloves (extended cuff nitrile or surgical) on over the inner gloves.
- Pull gloves over the cuffs of the apron.

14 Inspection



Buddy inspects to ensure **HCW** PPE is secure and all closures are flat before the **HCW** enters the room.

9.3 Health Care Worker with Fluid Resistant Gown Doffing

Health Care Worker with Fluid Resistant Gown
Doffing of Personal Protective Equipment
For Ebola Suspect or Confirmed Wet Patient

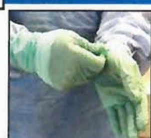
November 12, 2014

Note: PPE Buddy remains on the "clean" side to assist with doffing.

1 Remove Visible Soil from PPE

- If there is visible soil on PPE:
  - **HCW** will soak up all body fluids with an absorbent product (incontinence pad, etc.) using a blotting action. Immediately discard the product into biohazard containers.
  - Wipe the affected spots of PPE with a recommended disinfectant wipe and allow to dry. Immediately discard wipe in the biohazard container.
- If gloves become contaminated, use a recommended disinfectant wipe to remove contamination and allow to dry. Immediately discard wipe in the biohazard container.

2 Outer Gloves



On the contaminated side:

- Remove outer gloves with care.
- Minimize direct contact with inner gloves
- Drop gloves in biohazard container

3 Apron

A **Buddy** unties apron back and gently tears apart perforated neckline.

B **HCW** pulls thumb loops loose.

C **HCW** slides hands into apron. With hands inside apron sleeves, the **HCW** pulls apron off using the outer surfaces of apron.

D **HCW** gently folds up apron and drops into biohazard container.

4 Face Shield

HCW removes own face shield.

- Pull the back strap gently, lift over head and away from face
- Drop face shield in biohazard container

5 Surgeon's Hoods

A Neck Cover

1. **Buddy** unties the surgeon's hood at the back of the neck.
2. **Buddy** passes ties forward to the **HCW**. **HCW** pulls off and drops hood in biohazard container.

B Head Cover

1. **Buddy** unties from behind **HCW**
2. **Buddy** passes ties forward to **HCW**
3. **HCW** uncrosses ties at the front and passes them back to the **Buddy**.
4. **Buddy** removes the hood by holding ties back and pulling hood backwards. **Buddy** drops hood into biohazard container.

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Health Care Worker with Fluid Resistant Gown
Doffing of Personal Protective Equipment For Ebola Suspect or Confirmed Wet Patient

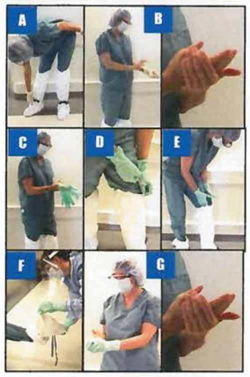
November 12, 2014

6 Gown

Buddy unties the gown

- **HCW** eases gown forward and outward
- **HCW** drops gown into biohazard container

7 Leg Covers



A With legs apart, **HCW** reaches down to untie straps.
B **HCW** removes inner gloves **and performs Hand Hygiene.**
C **HCW** dons new, clean gloves.
D **HCW**, while standing, cuts top elastic at front of each leg covering and discards scissors in sharps container.
E **HCW** puts gloved hands inside leg coverings, pushes each leg covering down turning inside out to ankle.
F **HCW** sits. **HCW** removes leg cover over foot or **Buddy** pulls off.

- **HCW** puts each foot on clean side of the room as it is removed from the leg cover.

G **HCW** removes gloves and performs Hand Hygiene.

Note: ***Do not*** cross your legs while sitting. Crossing your legs **will contaminate your scrubs.**

8 Bouffant Hair Cover

HCW removes own hair cover.

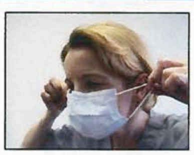
- Pull backwards off of head.
- Drop hair cover into biohazard container.

9 Eye Protection

HCW removes own eye protection.

- Hold arms of glasses.
- Carefully remove from face.
- Drop glasses into biohazard container.

10 Mask or N95 Respirator



HCW removes own mask.

- Bend slightly forward and remove by grasping only by loops.
- Drop mask into biohazard container.
- **Do not** touch front of mask.

If an **N95 respirator** was used, remove it using the same process as the mask. Remove the bottom band first.

11 Hand Hygiene

A Use an alcohol-based hand rub, the preferred way to clean your hands.
B If your hands look or feel dirty, soap and water **must** be used to wash your hands.

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Alberta Health Services

9.4 Health Care Worker With Coveralls Donning

November 12, 2014

Health Care Worker with Coveralls

Donning of Personal Protective Equipment

For Ebola Suspect or Confirmed Wet Patient

All HCWs will wear hospital supplied scrubs under the PPE, as well as clean, sturdy, fully-enclosed footwear.

1 Preparation

- Pull your hair back and secure it off your neck and face.
- Remove all extra items on your person. This includes, but is not limited to:
  - Jewellery, watches
  - Stethoscopes
  - ID tags, lanyards
  - Pagers, phone, etc.

2 Hand Hygiene

A Use an alcohol-based hand rub, the preferred way to **clean your hands.**

B If your hands look or feel dirty, soap and water **must** be used to wash your hands.

3 Body Suit

- Step into body suit, pull up over shoulders and put arms in arm holes.
- Do not put on hood.
- Do not zip up.

4 Shoe Covers

- Pull shoe covers on over feet of body suit.

5 Hand Hygiene

- Use an alcohol-based hand rub, the preferred way to clean your **hands**.

6 Surgical (Inner) Gloves

A Put on surgical gloves.

B Pull the cuffs of the suit over the cuff of gloves.

7 Mask or N95 Respirator

A Surgical or Procedural Mask:

- Put ear loops over ears.
- Pinch nose piece to fit bridge of nose.

B N95 Respirator (for aerosol generating medical procedures):

- Stretch out elastic bands, cup N95 in one hand and hold to face.
- Put top elastic on crown of head first, then put bottom elastic at base of head.
  - Test for appropriate fit.

8 Eye Protection

- Place over eyes.
- Adjust to fit.

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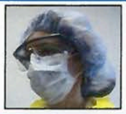
Alberta Health Services

November 6, 2014

Health Care Worker with Coveralls
Donning of Personal Protective Equipment
For Ebola Suspect or Confirmed Wet Patient

9 Bouffant Hair Cover



- Ensure all hair is covered by bouffant to prevent hair falling forward.

10 Coverall Hood and Zipper Seal

A **HCW** pulls up coverall hood.
B **HCW** fully zips-up the coverall.
C Seal the flap of the coverall.
- **Buddy** peels the backing off the coverall flap.
- **Buddy** holds the flap flat and straight.
- **HCW** presses the flap closed carefully to ensure there are no folds or bubbles.
- **Buddy** or **HCW** presses firmly on the top of the flap for a few seconds to ensure it is well sealed.

11 Apron

Make sure the apron covers from neck to knees and to wrist.
A **HCW** inserts thumbs in the loops in the sleeves.
B **Buddy** helps put on apron and ties at the back.

12 Surgeon's Hood

A **HCW** puts on hood and crosses ties at the front.
B **Buddy** adjusts the front, ensuring ties lay flat, and ties at back of the neck.

13 Face Shield

- Place the face shield over your face.
- Adjust to fit.

14 Outer Gloves

A Put a second pair of gloves (extended cuff nitrile or sterile) on over the inner gloves
B Pull gloves over the cuffs of the apron
C **Buddy** may assist if necessary

15 Inspection

- **Buddy** inspects to ensure **HCW** PPE is secure and all closures are flat before the **HCW** enters the room.

Either the yellow or blue coverall may be worn.

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Alberta Health Services

9.5 Health Care Worker with Coveralls Doffing

Health Care Worker with Coveralls
Doffing of Personal Protective Equipment
For Ebola Suspect or Confirmed Wet Patient

November 12, 2014

Note: PPE Buddy, wearing appropriate PPE, remains on "clean" side to assist with doffing.

1 Remove Visible Soil from PPE

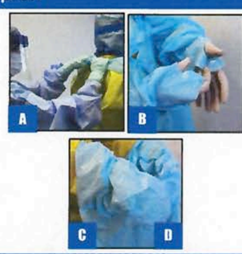
- If there is visible soil on PPE:
  - **HCW** will soak up all body fluids with an absorbent product (incontinence pad, etc.) using a blotting action. Immediately discard the product into biohazard containers.
  - Wipe the affected spots of PPE with AHS or hospital approved disinfectant wipe and allow gloves to dry. Immediately discard wipe in the biohazard container.
- If gloves become contaminated, use AHS or hospital approved disinfectant wipe to remove contamination and allow to dry. Immediately discard wipe in the biohazard container.

2 Outer Gloves

On the contaminated side:

- Remove outer gloves with care.
- Minimize direct contact with inner gloves.
- Drop gloves in biohazard container.

3 Apron



A **Buddy** unties apron back and gently tears apart perforated neckline.

B **HCW** pulls thumb loops loose.

C **HCW** slides hands into apron sleeves. With hands inside apron sleeves, the **HCW** pulls apron off using the outer surfaces of apron.

D **HCW** gently folds up apron and drops it into biohazard container.

4 Face Shield

HCW removes own face shield.

- Pull the back strap gently, lift over head and away from face.
- Drop face shield in biohazard container.
- Do not touch front of face shield.

5 Surgeon's Hood

A **Buddy** unties from behind the **HCW** and passes ties forward to **HCW**.

B **HCW** uncrosses ties at the front and passes them back to the **Buddy**.

C **Buddy** removes the hood by holding ties back and pulling hood backwards. **Buddy** drops hood into biohazard container.

6 Buddy's Gloves

A **Buddy** removes gloves and performs hand hygiene.

B **Buddy** puts on new gloves.

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Alberta Health Services

Health Care Worker with Coveralls

Doffing of Personal Protective Equipment For Ebola Suspect or Confirmed Wet Patient

November 12, 2014

7 Coverall

A Buddy un-sticks flap and un-zips coverall.

B Buddy removes gloves and performs Hand Hygiene and puts on new gloves.

C Buddy stands behind the HCW (on the clean side), reaches over the HCW, and grabs the inside the hood and rolls it backward off of the head so the outside surface is rolled in on itself.

D Buddy rolls the coverall off the shoulders. HCW holds arms at side, slightly away from the body so the Buddy can roll the coverall off their arms. Buddy continues to roll suit down to ankles.

- Be very careful not to put hands inside the coverall and touch the scrubs.

E HCW removes inner gloves and performs hand hygiene.

F HCW puts on new set of gloves.

G HCW sits. Buddy or HCW, touching inside surface of the coverall, pulls off coverall, one foot at a time, and drops coverall into biohazard container. Shoe covers will be removed with the coverall as one piece.

- HCW places each foot on clean side of doffing area as it's removed from coverall.

8 Outer Gloves

A HCW and Buddy remove their gloves and drop gloves into biohazard container.

B HCW and Buddy both perform Hand Hygiene.

9 Bouffant Hair Cover

HCW removes own hair cover.

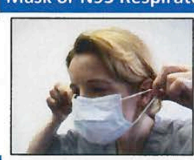
- Pull backwards off of head.
- Drop hair cover into biohazard container.

10 Eye Protection

HCW removes own eye protection.

- Hold arms of glasses.
- Carefully remove from face.
- Drop glasses into biohazard container.

11 Mask or N95 Respirator



HCW removes own mask.

- Bend slightly forward and remove by only grasping loops.
- Drop mask into biohazard container.
- **Do not** touch front of mask.

If an **N95 respirator** was used, remove it using the same process as the mask. Remove the bottom band first.

12 Hand Hygiene

A Use an alcohol-based hand rub, the preferred way to clean your hands.

B If your hands look or feel dirty, soap and water **must** be used to wash your hands.

9.6 PPE Buddy Donning

November 12, 2014

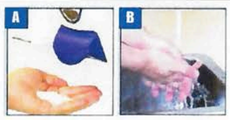
PPE Buddy
Donning of Personal Protective Equipment
For Ebola Suspect or Confirmed Patient

All health care workers (HCWs) will wear hospital supplied scrubs under the PPE, as well as clean, sturdy, fully-enclosed footwear.

1 Preparation

- Pull your hair back and secure it off your neck and face.
- Remove all extra items on your person. This includes, but **is not limited to**:
  - Jewellery, watches
  - ID tags, lanyards
  - Stethoscopes
  - Pagers, phones, etc.

2 Hand Hygiene



A Use an alcohol-based hand rub, the preferred way to **clean your hands.**

B If your hands look or feel dirty, soap and water **must** be used to wash your hands.

3 Shoe Covers

A Sit on a chair or stool.

B Fit a shoe cover completely over each shoe.

4 Hand Hygiene

- Use an alcohol-based hand rub, the preferred way to **clean your hands**.

5 Fluid Impervious Gown

A Make sure the gown covers from neck to knees and to wrist.

B Tie at the back of neck and waist.
- **Another person** may assist with ties.

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Alberta Health Services

November 12, 2014

PPE Buddy
Donning of Personal Protective Equipment For Ebola Suspect or Confirmed Patient

6 Mask

- Surgical or Procedural Mask
    - Put ear loops over ears.
    - Pinch nose piece to fit bridge of nose.

7 Bouffant Hair Cover

- Ensure all hair is covered by bouffant to prevent hair falling forward.

8 Face Shield

- Place the face shield over your face.
- Adjust to fit.

9 Outer Gloves

- Put a pair of extended cuff nitrile or surgical gloves on.
- Put the cuffs of the gloves over the cuffs of the gown.

10 Ready to Assist

- You are now ready to assist with doffing PPE of HCWs caring for suspect or confirmed Ebola patients.

9.7 PPE Buddy Doffing

PPE Buddy
Doffing of Personal Protective Equipment
For Ebola Suspect or Confirmed Patient

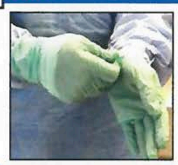
November 12, 2014

If PPE Buddy performs any tasks on the contaminated side of the donning/doffing area, they must start doffing on the contaminated side.

1 Remove Visible Soil from PPE

- If there is visible soil on PPE:
  - **HCW** will soak up all body fluids with a disposable, absorbent product (incontinence pad, etc.) using a blotting action. Immediately discard the product into biohazard containers.
  - Wipe the affected spots of PPE with AHS or hospital approved disinfectant wipe and allow to dry. Immediately discard wipe in the biohazard container.
- If gloves become contaminated, use AHS or hospital approved disinfectant wipe to remove contamination and allow to dry. Immediately discard wipe in the biohazard container.

2 Gloves



- Remove outer gloves with care.
- Minimize direct contact with inner gloves.
- Drop gloves in biohazard container.

3 Hand Hygiene

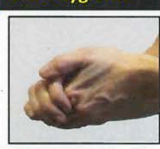
- Use an alcohol-based hand rub, the preferred way to **clean your hands.**

4 Gown

A **Another person puts on gloves** and unties the Buddy's gown.

B Buddy eases gown forward and outward.
- Drop gown into the biohazard container.

5 Hand Hygiene



- Use an alcohol-based hand rub, the preferred way to **clean your hands.**

6 Face Shield

- Pull the back strap gently and lift over head and away from face.
- Drop face shield in biohazard container.

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Alberta Health Services

November 12, 2014

PPE Buddy
Doffing of Personal Protective Equipment For Ebola Suspect or Confirmed Patient

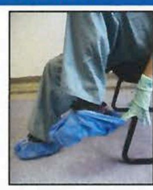
7 Hand Hygiene

- Use an alcohol-based hand rub, the preferred way to **clean your hands.**

8 Put on New Gloves

- Put on new gloves.

9 Shoe Covers



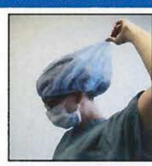
- Sit on a chair or stool.
- Remove shoe covers.
- Drop shoe covers into biohazard container.
- If you started doffing on the contaminated side, place each foot on the "clean" side of doffing area as each clean shoe is uncovered.

Note: ***Do not*** cross your legs while sitting. Crossing your legs **will contaminate your scrubs**.

10 Hand Hygiene

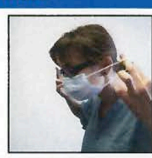
- Use an alcohol-based hand rub, the preferred way to **clean your hands.**

11 Bouffant Hair Cover



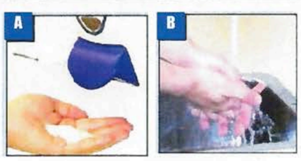
- Pull backwards off of head.
- Drop hair cover into biohazard container.

12 Mask



- Bend slightly forward and remove by only grasping the loops.
- Drop mask into biohazard container.
- **Do not** touch front of mask.

13 Hand Hygiene



A Use an alcohol-based hand rub, the preferred way to clean your hands.

B If your hands look or feel dirty, soap and water **must** be used to wash your hands.

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Alberta Health Services

9.8 EMS One-Piece Suit WET DONNING Procedure Checklist

VERSION
29 October 2014

EMS Response to Suspect Case - Ebola Virus Disease (EVD)

One-Piece Suit WET DONNING Procedure Checklist

BEFORE YOU BEGIN:

- Please use this checklist each time you don the suit
- Use the **buddy approach** when donning/doffing
- **One member dons** PPE while **the other assists** with donning process & ensures correct application of PPE using checklist
- This checklist is to be used following the Ebola POCRA and confirmed suspect case via MOH

STEP 1 - Prepare Stretcher/Ambulance/Equipment

- ❑ Remove all linen from stretcher - apply disposable sheets to stretcher - prepare to cocoon the patient
- ❑ All patients will be transported on the stretcher
- ❑ Remove unnecessary equipment, supplies, or personal items from rear compartment of ambulance
- ❑ Do not use the ePCR tablet in the contaminated zone
- ❑ Prepare for Blood & Bodily Fluid (BBF) spills - gather towels, solidifying agent, and emesis bag

STEP 2 - Perform Hand Hygiene

- ❑ Use alcohol-based hand rub

STEP 3 – Prepare/Inspect PPE Equipment

- ❑ Prepare the contents of the blue isolation kit. Each kit should contain: one-piece suits, N95 masks, gloves (2 types), goggles, face shield, duct tape, bouffant hair cap, boot covers, hand sanitizer, and biohazard bag (see equipment checklist in bag for full list)
- ❑ Inspect PPE for rips or damage and replace as necessary

STEP 4 - Prepare Personnel

- ❑ Remove any personal belongings from pockets
- ❑ Remove non-essential items (i.e. belt, drugs, radio, name tag)
- ❑ Put radio in cargo pocket & secure drugs per policy
- ❑ Clip radio microphone to shirt/tape cord to shirt. If radio has no microphone, place radio in plastic bag and carry

STEP 5 – Begin Donning One-Piece Suit

- ❑ Sit down and remove duty boots
- ❑ Don the one-piece suit to the waist line
- ❑ Don duty boots
- ❑ Don boot covers
- ❑ Do NOT tape boot covers

STEP 6 - Perform Hand Hygiene

- ❑ Use alcohol-based hand rub

STEP 7 – Continue Donning One-Piece Suit

- ❑ Pull the suit up and over shoulders

STEP 8 - Don N-95

- ❑ Don N-95
- ❑ Perform seal check

STEP 9 - Don Eye Protection and Cap

- ❑ Don goggles (the goggles will fit over your safety glasses)
- ❑ Don bouffant hair cap

STEP 10 - Finish Donning Suit - Hood & Zipper

- ❑ Pull suit hood over head
- ❑ Make a zipper tag with duct tape and zip up suit
- ❑ Seal zipper with taped flap on suit

Step 11 - Face Shield

- ❑ Don face shield

STEP 12 - Don Inner Gloves

- ❑ Don first pair of gloves (inner gloves) - pull suit cuff over top of gloves
- ❑ DO NOT TAPE

STEP 13 - Don Outer Gloves

- ❑ Don second pair of gloves (outer gloves) and pull gloves over suit cuff
- ❑ TAPE gloves to suit with duct tape

STEP 14 - Buddy Check

- ❑ Buddy inspects all PPE to ensure there are no gaps, tears, or other damage

9.9 EMS One-Piece Suit WET DOFFING Procedure Checklist

VERSION
29 October 2014

EMS Response to Suspect Case - Ebola Virus Disease (EVD)

One-Piece Suit WET DOFFING Procedure Checklist

BEFORE YOU BEGIN:

- Please use this checklist each time you doff the suit
- Use the **buddy approach** when doffing
- A third person in dry PPE is required to assist with doffing
- Establish a clean zone and a contaminated zone
- Monitor for contamination under PPE when doffing
- All PPE must be carefully placed in a biomedical hazardous waste bin
- A spare uniform and footwear must be readily available in the event of a breach in the PPE that contaminates the uniform

STEP 1 – Doff Boot Covers and Outer Gloves

- ❑ Medic – carefully removes boot covers while standing
- ❑ Buddy – Slowly removes tape from wrists
- ❑ Buddy – Slowly removes outside gloves by pinching cuff of glove and end of sleeve
- ❑ Medic – concurrently pulls arms inside sleeves

STEP 2 – Doff Face Shield and Doff Gloves

- ❑ Buddy – Removes medic's face shield (from back to front)
- ❑ Buddy - Doffs his/her own gloves

STEP 3 – Perform Hand Hygiene & Don Gloves

- ❑ Buddy – performs hand hygiene
  Use an alcohol-based hand rub
- ❑ Buddy – dons new gloves

STEP 4 – Begin Doffing One-Piece Suit

- ❑ Buddy – Un-sticks flap tape and unzips the suit
- ❑ Buddy – Goes behind medic
- ❑ Buddy – Starting at the hood rolls suit down to the knees turning it inside out
- ❑ Medic – Removes one arm at a time
- ❑ Medic – Crosses arms over chest once arms clear of suit

STEP 5 - Finish Doffing One-Piece Suit

- ❑ Medic - Sits down
- ❑ Medic - While seated, rolls suit down to boots

STEP 6 – Doff Boots

- ❑ Medic – Doffs boots using inside of suit

Please Note: If your duty boots are contaminated with Blood & Bodily Fluid (BBF), they MUST be placed in a biomedical hazardous waste bin

STEP 7 – Doff Inner Gloves

- ❑ Medic - Doffs inner gloves

STEP 8 – Perform Hand Hygiene

- ❑ Medic – performs hand hygiene
  Use an alcohol-based hand rub

STEP 9 - Don New Gloves and Doff Bouffant Cap

- ❑ Medic – Dons new gloves
- ❑ Medic – Doffs bouffant Cap

Step 10 – Doff Goggles

- ❑ Medic - Doffs goggles

STEP 11 – Doff N-95

- ❑ Medic – Doffs N-95

STEP 12 – Perform Hand Hygiene

- ❑ Medic – Performs hand hygiene
  Use an alcohol-based hand rub

STEP 13 - Buddy Check

- ❑ Buddy – doffs PPE as per Dry PPE Checklist

9.10 AHS Heat Strain While Wearing PPE Documentation

What is Heat Strain?

Heat Strain is how your body responds to a higher than normal heat load. The PPE you're wearing, environmental factors such as room temperature, and the work being performed will affect how your body will react.

What Are the Symptoms of Heat Strain?

The Warning signs of Heat Strain include one or more of:

- Inattention and Confusion
- Clumsiness
- Nausea
- Dizziness
- Light-headedness
- Severe Fatigue
- Increased Heart Rate

It is important to monitor yourself and your co-workers for these signs and take action if they occur.
If you experience any of these signs, **stop working, doff your PPE and take a rest break until you feel better.**

Why is it Important to Know about Heat Strain?

Heat Strain can impair your ability to perform your work duties and may affect how well you will doff your PPE. It is critical that you are alert and attentive while doffing in order to avoid possible self contamination. Preventing Heat Strain is the best strategy in ensuring work duties are performed as expected and self contamination is prevented.

Preventing Heat Strain

To Avoid Heat Strain:

- Pre-hydrate with non caffeinated fluids before donning your PPE
- Your response to wearing the PPE will determine your ideal work duration and rest requirements.
- Initially, you should work for no more than 30-45 minutes in a one hour period; the remainder of that one hour period should be spent resting
- This is not a strict cut off. The work cycle may be shortened or lengthened depending on the work being performed and how you're feeling
- The rest time should be spent in an area with a comfortable temperature that allows you to cool off and re-hydrate.
- Drinking water must be available in the rest area.

Alberta Health Services