**Supplementary Materials for**

**A Bacteriophage-based Validation of a Personal Protective Equipment Doffing Procedure to be Used with High Consequence Pathogens**

**Supplementary Table 1: Analysis of Movie – Adherence to Doffing Protocol**

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| **HCP** | **Deviations** |
| HCP 1 | Did not take off outer gloves before undoing PAPR ties |
| HCP 2 | Poor hand sanitization (duration) |
| HCP 3 | Poor hand sanitization (duration and technique) |
| Excessive contact with PAPR hood at most steps |
| Skipped hand sanitization at multiple steps |
| HCP 4 | None |
| HCP 5 | Poor hand sanitization (duration) |
| Poor gown rolling |
| Excessive contact with PAPR hood |
| HCP 6 | None |
| HCP 7 | Folding gown near body |
| Unzipping coverall while touching PAPR |
| HCP 8 | None |
| HCP 9 | Gown touched PAPR |

**Supplementary Table 2. Critical densities for pathogens of concern**

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| **Pathogen** | **High Limit of Pathogen Density Commonly Found in Patient Samples** | **Reported Minimum Infective Dose** |
| *Ebolavirus spp. [8, 9]* | 1x107 PFU/mL | 1 to 10 Virions |
| *Alphainfluenzavirus sp. [10, 11]* | 5x105 PFU/mL | 4 Virions |
| *Mycobacterium tuberculosis [12, 13]* | 5x105 CFU/mL | 1 to 200 Bacteria |
| *Betacoronavirus MERS-CoV [14, 15]* | 1x107 PFU/mL | 200 to 1000 Virions |
| *Orthopoxvirus Variola virus [8, 16]* | 5x105 CFU/mL | 10 to 100 Virions |
| *Yersinia pestis [17, 18]* | 1x109 CFU/mL | 1 to 10 Bacteria |

**Supplementary Table 3. Donning Stepwise Procedure**

Steps written in bold font indicate updated steps in the new donning procedure.

|  |  |  |
| --- | --- | --- |
| **Step Number** | **Original Donning Procedure** | **Updating Donning Procedure** |
| **1** | Qualified monitor is present. | Qualified monitor is present. |
| **2** | Set up cart for donning and doffing. | Set up cart for donning and doffing. |
| **3** | Remove personal effects (phone, keys, badges, pens, etc.). | Remove personal effects (phone, keys, badges, pens, etc.). |
| **4** | Put on inner gloves. | Put on inner gloves. |
| **5** | Secure belt snug around waist with clip facing up. Place excess belt into clip and loop. | **Don clear inner boot liners over shoes and pants.** |
| **6** | Secure the battery on the left side of the belt. | Secure belt snug around waist with clip facing up. Place excess belt into clip and loop. |
| **7** | Connect helmet to battery. | Secure the battery on the left side of the belt. |
| **8** | Check that 3 LED lights are green to ensure battery is fully charged. | Connect helmet to battery. |
| **9** | Adjust temple holder (top hole for larger head, 2nd hole works for most though). | Check that 3 LED lights are green to ensure battery is fully charged. |
| **10** | Put helmet on head and size to fit by turning ratchet knob to adjust the headband. | Adjust temple holder (top hole for larger head, 2nd hole works for most though). |
| **11** | Bend over to ensure helmet is tight enough to stay on without slipping. | Put helmet on head and size to fit by turning ratchet knob to adjust the headband. |
| **12** | Ensure long hair is in a low bun or ponytail is above shoulders. | Bend over to ensure helmet is tight enough to stay on without slipping. |
| **13** | Adjust fan speed to comfort. | Ensure long hair is in a low bun or ponytail is above shoulders. |
| **14** | Disconnect the battery. | Adjust fan speed to comfort. |
| **15** | Open the hood bag. | Disconnect the battery. |
| **16** | Set aside outer heavy loading filter. | Open the hood bag. |
| **17** | Orient the hood so markings face you and are in upward direction and flat edge is at top. | Set aside outer heavy loading filter. |
| **18** | Hold the upper corners and shake the hood until it fully unfolds. | Orient the hood so markings face you and are in upward direction and flat edge is at top. |
| **19** | Connect the center hole of the hood to the center hook on the front of the helmet. Once you are hooked, keep pushing until you hear a snap. | Hold the upper corners and shake the hood until it fully unfolds. |
| **20** | Connect the right and left sides of the hood to the helmet in the same way until you hear a snap. | Connect the center hole of the hood to the center hook on the front of the helmet. Once you are hooked, keep pushing until you hear a snap. |
| **21** | Grab the bottom of the hood and pull it back and over the helmet until it fits. | Connect the right and left sides of the hood to the helmet in the same way until you hear a snap. |
| **22** | Take the heavy loading filter and fit it fully over the top of the hood. | Grab the bottom of the hood and pull it back and over the helmet until it fits. |
| **23** | Set assembled PAPR hood aside. | Take the heavy loading filter and fit it fully over the top of the hood. |
| **24** | Put on coveralls outside room. Feet in first. Open-end faces your front. Do not zip up yet. | Set assembled PAPR hood aside. |
| **25** | Ensure proper mobility of arms and legs within coveralls. | Put on coveralls outside room. Feet in first. Open-end faces your front. Do not zip up yet. |
| **26** | Tape coverall and wrist of the gloves, forming a release tab at end of the loop. | Ensure proper mobility of arms and legs within coveralls. |
| **27** | Put on pair of extended cuff outer gloves. | Tape coverall and wrist of the gloves, forming a release tab at end of the loop. |
| **28** | Don booties. | Don booties. |
| **29** | Sanitize gloves and touched dispenser. | Sanitize gloves and touched dispenser. |
| **30** | Insert PAPR power cord connector into the battery. | Insert PAPR power cord connector into the battery. |
| **31** | Put the helmet on, letting the hood drape around your shoulders over the coveralls. Last chance to adjust the helmet. | Put the helmet on, letting the hood drape around your shoulders over the coveralls. Last chance to adjust the helmet. |
| **32** | Tuck the cord into your coverall. | Tuck the cord into your coverall. |
| **33** | Zip up the front of the coveralls. | Zip up the front of the coveralls. |
| **34** | Insert fingers into facial liner and tug it around your face until it tucks under your chin. | Insert fingers into facial liner and tug it around your face until it tucks under your chin. |
| **35** | Find both neck ties and bring them to the front and tie a shoelace knot close to neck. | Find both neck ties and bring them to the front and tie a shoelace knot close to neck. |
| **36** | Grab both torso ties off of back, bring them around and insert them through the front of the hood insertion holes, then tie into shoelace knot. | Grab both torso ties off of back, bring them around and insert them through the front of the hood insertion holes, then tie into shoelace knot. |
| **37** | Tear neck loop of apron. | **Don gown.** |
| **38** | Tie apron on around neck. Hood should be underneath apron. | **Secure neck of gown, making sure neck tie of hood is covered.** |
| **39** | Tie apron around waist. | **Tie gown at waist in back.** |
| **40** | Monitor completes 360º check of PP. | **Put on pair of extended cuff outer gloves, securing gown sleeve inside of the extended cuff glove.** |
| **41** | Sanitize gloves and touched dispenser. | Monitor completes 360º check of PP |
| **42** | Enter room. Do not enter room without proper fit of the PAPR system. | Sanitize gloves and touched dispenser. |
| **43** | Do not touch or re-adjust PAPR system inside the room. | Enter room. Do not enter room without proper fit of the PAPR system. |
| **44** |  | Do not touch or re-adjust PAPR system inside the room. |

**Supplementary Table 4. Doffing Stepwise Procedure**

Steps written in bold font indicate updated steps in the new donning procedure.

|  |  |  |
| --- | --- | --- |
| **Step Number** | **Original Doffing Procedure** | **Updating Doffing Procedure** |
| **1** | Check that your partner outside of the room is aware you are preparing to doff. | Check that your partner outside of the room is aware you are preparing to doff. |
| **2** | Inspect PPE for obvious soiling or contamination. Have your partner inspect your back through the window on the door. | Inspect PPE for obvious soiling or contamination. Have your partner inspect your back through the window on the door. |
| **3** | Wipe away contamination with EPA-approved disinfectant wipes. | Wipe away contamination with EPA-approved disinfectant wipes. |
| **4** | Place a non-slip chuck pad in front of the door. | Place a non-slip chuck pad in front of the door. |
| **5** | Ensure that you have sanitizer and trash can within reach of pad. | Ensure that you have sanitizer and trash can within reach of pad. |
| **6** | Sanitize gloves and touch dispenser. | Sanitize gloves and touch dispenser. |
| **7** | Grab the apron under the arms at the base of each tie. | **With one hand, reach up to back of helmet and remove heavy loading filter from top of PAPR hood, throw into trash.** |
| **8** | Pull forward until back ties break. | Sanitize gloves and touched dispenser. |
| **9** | Pull apron down until neck ties break. | **Gently pull the sleeves of the gown free from each outer glove cuff.** |
| **10** | Bring your hands together until the apron folds vertically. | Sanitize gloves and touched dispenser. |
| **11** | Roll up while keeping arms extended. | **Grasp gown at sides over waist tie, pull forward to break tie.** |
| **12** | Discard apron into trash. | **Cross your arms to grasp gown at upper arm/ shoulder, avoid touching PAPR hood.** |
| **13** | Sanitize gloves and touched dispenser. | **Uncross your arms slowly, inverting the gown and extending your arms outward until they are outstretched. Keeping arms extended away from your body, bundle the gown and discard.** |
| **14** | Choose one hand to remove one bootie. As you remove it, step with that foot onto pad. Throw bootie away. | Sanitize gloves and touched dispenser. |
| **15** | Use same hand to remove other bootie, if you can balance properly. Use CPR stand or tall trash can to aid in balance and step onto pad. Throw bootie away. | Choose one hand to remove one bootie. As you remove it, step with that foot onto pad. Throw bootie away. |
| **16** | Sanitize gloves and touched dispenser. | Use same hand to remove other bootie, if you can balance properly. Use CPR stand or tall trash can to aid in balance and step onto pad. Throw bootie away. |
| **17** | Remove outer gloves using beaking technique and throw away. | Sanitize gloves and touched dispenser. |
| **18** | Sanitize gloves and touched dispenser. | Remove outer gloves using beaking technique and throw away. |
| **19** | Remove the heavy loading filter into the trash can. | Sanitize gloves and touched dispenser. |
| **20** | Sanitize gloves and touched dispenser. | **Untie the necktie of the PAPR hood, gathering it together, and discard.** |
| **21** | Undo or break just the neck ties and throw into trash. | Sanitize gloves and touched dispenser. |
| **22** | Sanitize gloves and touched dispenser. | Grab torso ties of hood and undo or break those ties and throw into trash. |
| **23** | Grab torso ties of hood and undo or break those ties and throw into trash. | Sanitize gloves and touched dispenser. |
| **24** | Sanitize gloves and touched dispenser. | Remove tape from both wrists using tabs and throw into trash. |
| **25** | Remove tape from both wrists using tabs and throw into trash. | Sanitize gloves and touched dispenser. |
| **26** | Sanitize gloves and touched dispenser. | Zip down coveralls. |
| **27** | Zip down coveralls. | Grasp coveralls around lower back area and pull down. |
| **28** | Grasp coveralls around lower back area and pull down. | Remove coveralls from shoulders and pull down below knees, touching only inside to inside. |
| **29** | Remove coveralls from shoulders and pull down below knees, touching only inside to inside. | **March and stomp out of the coveralls. Do not use your hands to remove.** |
| **30** | March and stomp out of the coveralls. Do not use your hands to remove. | Step off and leave coverall for next person to pick up. |
| **31** | Step onto leg of coverall and slowly kick backwards to get each foot out. | Sanitize gloves and touched dispenser. |
| **32** | Step off and leave coverall for next person to pick up. | Observer opens door. |
| **33** | Sanitize gloves and touched dispenser. | Exit patient room. |
| **34** | Observer opens door. | Sanitize gloves and touched dispenser. |
| **35** | Exit patient room. | **Place both hands under the PAPR hood at the shoulders. Grasp the back portion of the PAPR hood and gather the material by rolling it together, touching the inside only.** |
| **36** | Sanitize gloves and touched dispenser. | **Continue to roll the hood material up across the back and top of the helmet until you reach the top of the head, in line with the ears.** |
| **37** | Grab shoulders of the hood, pull back, and lift over head. | **Move fingers to the edge of the face shield and unsnap the hood and shield from the PAPR visor, folding the shield away from the PAPR.** |
| **38** | Find edges of the visor and pop out the sides. | Do not touch your face. |
| **39** | Tilt head down and pull visor up and away from you and throw it away. | Sanitize gloves and touched dispenser. |
| **40** | Do not touch your face. | Remove inner gloves (beak method). |
| **41** | Sanitize gloves and touched dispenser. | Sanitize hands and touched dispenser. |
| **42** | Remove inner gloves (beak method). | Observer holds battery. |
| **43** | Sanitize hands and touched dispenser. | Observer unbuckles belt. |
| **44** | Observer holds battery. | Observer removes helmet motor from behind, avoiding the face. |
| **45** | Observer unbuckles belt. | Wash hands and arms thoroughly with soap and water. |
| **46** | Observer removes helmet motor from behind, avoiding the face. | Talk with your infection prevention team about showering protocols. |
| **47** | Wash hands and arms thoroughly with soap and water. |  |
| **48** | Talk with your infection prevention team about showering protocols. |  |

**Supplementary Table 5. PPE Ensemble and Purpose**

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| **Item** | **Ref Number** | **First/ Second/ Both Protocols** | **Purpose** |
| Disposable Scrubs | Halyard, USA, Pants: 47790, 47791, 47792, 47793; Tops: 47786, 47787, 47788, 47789 | Both | Disposal of potentially hazardous outer garments |
| Shoe Covers | MedLine, USA, #NON31859 | Both | Prevent bodily fluids from contaminating shoes of HCP  |
| Shoe Liners | ULine, USA, S-19250 | Second | Facilitate easier removal of coveralls from shoes |
| Inner Gloves  | Halyard, USA, GLV2304 | First | Exam gloves, prevent contamination from spreading to hands of HCP |
| Halyard, USA, #55095 | Second | Long cuff gloves, provide additional protection to forearms of HCP |
| Outer Gloves | Halyard, USA #53141, | Second | Long cuff gloves, prevent contaminants from reaching inner cuff of coveralls |
| Halyard, USA, 50602 | First | Long cuff gloves, prevent contaminants from reaching inner cuff of coveralls |
| Tape |  Grainger, USA #H6195 | Both | Seal outer gloves to coveralls |
| Gown | Life Science Products, USA, #GO-633VPE,  | Second | Provide complete coverage to outer layer of protection to patient-facing surfaces |
| Apron | Halyard, USA, #A7779 | First | Provide a front outer layer of protection to patient-facing surfaces |
| Coveralls | International EnviroGuard, USA, W2501 | Both | Complete body covering  |
| PAPR Belt Pack | MaxAir, USA, Belt: 2000-76; Battery: 2500-36TSC Li-Ion Battery | Both | Hold PAPR battery to supply power to respirator |
| PAPR Helmet | MaxAir, USA, 2084-03 Helmet - Helmet, Liner, Power Cord | Both | Provide shape and mount for PAPR hood  |
| PAPR Hood |  MaxAir, USA, 2281PR-100  | Both | Prevent contamination to head and mucosal membranes of HCP |
| PAPR Heavy Loading Filter  |  MaxAir, USA, 2172-97 | Both  | Provide an additional filtration to PAPR  |