Use of Fluorescence Photography Method in Identifying Risks and Optimum Sequence of Removing Personal Protective Equipment for Infection Control Purpose

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The battle against disease has been helped by understanding the relationships between micro-organisms, humans and other species, and how they are affected by environmental changes. ‘Epidemic: The World of Infectious Disease’ provides an imaginative, graphic, lively and interactive history of various infections. Ongoing at the American Museum of Natural History. Tel 789 5800.
### Cumulative Number of Confirmed Human Cases of Avian Influenza A/(H5N1) Reported to WHO

**18 March 2008**

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**Updates from WHO on 28 March 2008**
Weekly consultation of influenza-like illness reported by GOPC and GP in 2007 and 2008

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Weekly consultation rates of influenza-like illness reported by General Out-patient Clinics (GOPC) and General Practitioners (GP) 2007

For the week ending | Rate (per 1000 consultations) |
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Updates from CHP on 28 March 2008
Types of PPE Used in Healthcare Settings

- Gloves – protect hands
- Gowns/aprons – protect skin and/or clothing
- Surgical masks and respirators – protect mouth/ nose
- Goggles – protect eyes
- Face shields – protect face, mouth, nose, and eyes
- Optional use:
  - Boots, cap
High Risk Procedures

- Bronchoscopy
- Nasal pharyngeal aspiration
- Tracheal tube insertion
- Open circuit suctioning
- Use of nebulizers or puff
- Other cough producing or aerosol generating procedures
Aerosol-Generating Procedures

- OSHA
  - Endotracheal intubation
  - Aerosolized or nebulized medication administration
  - Sputum induction/collection
  - Bronchoscopy
  - Airway suctioning
  - +ve pressure ventilation via face masks
  - High-frequency oscillatory ventilation
Aerosol-Generating Procedures

- Documented increase in risk of respiratory pathogen transmission
  - Intubation, CPR
  - Bronchoscopy
  - Autopsy / surgery
- Controversial / possible increase in risk of respiratory pathogen transmission
  - Non-invasive +ve pressure ventilation and bilevel +ve airway pressure
  - High-frequency oscillating ventilation
  - Nebulization
**Personal Protective Equipment (PPE) Removal**

**Before LEAVING Negative Air Space**

Note: Discard used items in red bag.

**STEP 1**

**Facemask**

Remove and discard.

**STEP 2**

**Headcover**

Remove and discard.

**STEP 3**

**Shoe covers**

Remove and discard.

**STEP 4**

**Gown & Gloves**

Grasp shoulders of gown and pull forward. Roll outside of gown inward, folding contaminated outside layer away from your body.

**STEP 5**

**Hand Hygiene**

Clean hands with antimicrobial soap and water or alcohol-based hand rub.

**STEP 6**

**N95 Respirator**

Front of respirator is contaminated. Handle only the bands. To remove, pull lower band over the head first, then remove upper band. Discard.

**STEP 7**

**Hand Hygiene**

Clean hands with antimicrobial soap and water or alcohol-based hand rub.

Note: If Powered Air Purifying Respirator (PAPR) is used, follow facility procedures for applying, removing, and processing equipment. PAPR or tight-fitting goggles should be worn for high-risk aerosol-generating procedures.
SEQUENCE FOR REMOVING PERSONAL PROTECTIVE EQUIPMENT (PPE)

Except for respirator, remove PPE at doorway or in anteroom. Remove respirator after leaving patient room and closing door.

1. GLOVES
   - Outside of gloves is contaminated!
   - Grasp outside of glove with opposite gloved hand; peel off
   - Hold removed glove in gloved hand
   - Slide fingers of ungloved hand under remaining glove at wrist
   - Peel glove off over first glove
   - Discard gloves in waste container

2. GOGGLES OR FACE SHIELD
   - Outside of goggles or face shield is contaminated!
   - To remove, handle by head band or ear pieces
   - Place in designated receptacle for reprocessing or in waste container

3. GOWN
   - Gown front and sleeves are contaminated!
   - Unfasten ties
   - Pull away from neck and shoulders, touching inside of gown only
   - Turn gown inside out
   - Fold or roll into a bundle and discard

4. MASK OR RESPIRATOR
   - Front of mask/respirator is contaminated — DO NOT TOUCH!
   - Grasp bottom, then top ties or elastics and remove
   - Discard in waste container

PERFORM HAND HYGIENE IMMEDIATELY AFTER REMOVING ALL PPE

Courtesy of CDC (2004)

SECUENCIA PARA QUITARSE EL EQUIPO DE PROTECCIÓN PERSONAL (PPE)

Con la excepción del respirador, quítense el PPE en la entrada de la puerta o en la antecámara. Quítense el respirador después de salir de la habitación del paciente y de cerrar la puerta.

1. GUANTES
   - ¡El exterior de los guantes está contaminado!
   - Agarre la parte exterior del guante con la mano opuesta en la que todavía tiene puesto el guante y quíteselo
   - Sostenga el guante que se quitó con la mano enguantada
   - Deslíce los dedos de la mano sin guante por debajo del otro guante que no se ha quitado todavía a la altura de la muñeca
   - Quite el guante de manera que acabe cubriendo el primer guante
   - Arróje los guantes en el recipiente de desechos

2. GAFAS PROTECTORAS O CARETA
   - ¡El exterior de las gafas protectoras o de la careta está contaminado!
   - Para quitárselas, tómelas por la parte de la banda de la cabeza o de las piezas de los ojos
   - Colóquelas en el recipiente designado para reaprocesar materiales o de materiales de desecho

3. BATA
   - ¡La parte delantera de la bata y los mangos están contaminados!
   - Desate los cordones
   - Tomando solamente el interior de la bata, pásela por encima del cuello y de los hombros
   - Vuelva la bata al revés
   - Dóblela o enróllela y deséchela

4. MÁSCARA O RESPIRADOR
   - La parte delantera de la máscara o respirador está contaminado — ¡NO LA TOQUE!
   - Primero agarre la parte de abajo, luego los cordones o banda elástica de arriba y por último quítense la máscara o respirador
   - Arrójela en el recipiente de desechos

EFFECTúE LA HIGIENE DE LAS MANOS INMEDIATAMENTE DESPUÉS DE QUITARSE CUALQUIER EQUIPO DE PROTECCIÓN PERSONAL
Order for Removing PPE

- Upon leaving the room, HHS/CDC recommends that PPE be removed in a way to avoid self-contaminations, as follows:
  - Gloves
  - Faceshield or goggles
  - Gown
  - Respirator or mask

(OSHA, 2007)
Order for Removing PPE

1. Remove and dispose gloves & gown
   - Avoid contamination of self, others & the environment
   - Remove the most heavily contaminated items first
   - Remove gloves & gown:
     - peel off gown & gloves and roll inside, out
     - dispose gloves and gown safely

2. Hand Hygiene

3. Remove and dispose cap (if worn)
   - Remove cap (if worn)
   - Remove goggles from behind
   - Put goggles in a separate container for reprocessing

4. Remove goggles

5. Remove respirator from behind

6. Hand hygiene

(WHO, 2007)
Local Recommendations by CHP

1. Remove Gloves
2. Perform Hand Hygiene
3. Remove Gown
4. Perform Hand Hygiene
5. Remove Disposable Cap and Eye Protection
6. Perform Hand Hygiene (Optional)
7. Remove Mask / N95 Respirator
8. Perform Hand Hygiene AGAIN
Fluorescent Dye

Fluorescein sodium: 113.2 mg/mL
Dilution of 10% Fluorescein sodium: 1 in 500
Fluorescent Spraying

HCW in full PPE

Spray of fluorescent dyes

Atomizer

1 m

1 m
MeterJet™ Spray Gun

Adjustment for volume of each spray
MeterJet Spray Gun Connected to a Pressure Tank
Whole Set Up
Volume: 2 mL
Pressure applied: 75 psi
Photographic parameters

Camera: Nikon D200 DSLR
Lens: Nikon ED 28-70 1:2.8D
Shutter Speed: 1.3s
Aperture: f/2.8
ISO Value: 1600
White Balance: 6000K
UV Filter
Image Analyzing Applications
Baseline

Total Coverage: 0.0000%
Methods

- 10 Subjects recruited assuming the effect size was 1.25 and the power was 0.746
- Fluorescent dye sprayed
- Sequence A (glove > gown > cap > face shield > goggle > respirator)
- Sequence B (face shield > goggle > cap > gown + glove > respirator)
- Remove full-gear PPE four times
  - Sequence A (nice and slowly – 3 minutes)
  - Sequence A (roughly – 1 minute)
  - Sequence B (nice and slowly – 3 minutes)
  - Sequence B (roughly – 1 minute)
- Fluorescence photos taken under UV lights
Fluorescent dyes: 3 strokes applied to head, chest and trunk from 3 feet
Shutter Speed: 1.3s; Aperture: f/2.8; ISO Value: 1600 White Balance: auto -3
Degowning sequence: (A)
glove > gown > cap > face
shield > goggles > respirator
Time consumed: Nice and slow (3 minutes)
Degowning sequence: (A) glove > gown > cap > face shield > goggles > respirator
Time consumed: Roughly (1 minute)
Degowning sequence: (B) face shield > Goggles > cap > gown and gloves > respirator
Time consumed: Nice and slow (3 minutes)
Degowning sequence: (B) face shield > Goggles > cap > gown and gloves > respirator
Time consumed: Roughly (1 minute)
Total Coverage : 0.3415 %
Degowning sequence: (A) glove > gown > cap > face shield > goggles > respirator
Time consumed: Nice and slow (3 minutes)
Total Coverage : 0.0343 %
Degowning sequence: (A) glove > gown > cap > face shield > goggles > respirator

Time consumed: Roughly (1 minute)
Degowning sequence: (B) face shield > goggles > cap > gown and gloves > respirator
Time consumed: Nice and slow (3 minutes)
Total Coverage : 0.5492 %
Degowning sequence: (B) face shield > Goggles > cap > gown and gloves > respirator
Time consumed: Roughly (1 minute)
Degowning sequence: (A) glove > gown > cap > face shield > goggles > respirator
Time consumed: Nice and slow (3 minutes)
Degowning sequence: (A) glove > gown > cap > face shield > goggles > respirator
Time consumed: Roughly (1 minute)
Degowning sequence: (B) face shield>goggles>cap>gown and gloves>respirator
Time consumed: Nice and slow (3 minutes)
Total Coverage : 0.0281 %
Degowning sequence: (B) face shield>Goggles>cap>gown and gloves>respirator
Time consumed: Roughly (1 minute)
Experimental Design

- 2x2 factorial design with repeated measures
- 2x2
  - 2 factors, each with 2 levels
- Factorial design
  - Evaluate effects of 2 independent variables in one experiment
- Repeated measures
  - Same subjects participate in all conditions of an experiment
Correlation between sequences, carelessness of PPE removal and percentage of exposures on face

Nice and Slow

Roughly
Statistical Analysis

- Repeated measures ANOVA
Diagnostics

- **Sphericity (circularity)**
  - Mauchly’s test
  - Constant variances of differences between any two measurements within a subject
Results

Estimated Marginal Means of exposure

- Carelessness
  - 1 min carelessly
  - 3 min nice and slow
Results

Estimated Marginal Means of exposure

- Removal Sequence A
- Removal Sequence B

1 min carelessly vs. 3 min nice and slow
Results

- **Main effects**
  - Sequence: $p$-value=0.0031*
  - Carelessness: $p$-value=0.0070*

- **Interaction effect**
  - Sequence*Carelessness: $p$-value=0.1168
Conclusion

• Use of gloved hands in removing face shield and goggle causes substantial contamination on face and especially on forehead.
• When the cap was put outside of both face and eye protection, less forehead contamination was noted.
• Early removal of eye protection and potential aerosolization of dyes while removing the gown
• It makes difference when removing PPE carefully.
• Removing PPE carefully in sequence A incur less self facial contamination.
Acknowledgements

- Thanks to SEPO of HKUST
- Thanks those who sacrificed their beautiful faces to make this experiment successful!

THANK YOU

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