EUCIC advanced module
Infection prevention and control

PPE (Personal protective equipment)

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<table>
<thead>
<tr>
<th>Disclosure of speaker’s interests</th>
<th>None</th>
</tr>
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<tbody>
<tr>
<td>(Potential) conflict of interest</td>
<td>None</td>
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<tr>
<td>Potentially relevant company relationships in connection with event</td>
<td>None</td>
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<tr>
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<td>European Commission; European Centre for Disease Prevention and Control; Swissnoso; Federal Office of Public Health Switzerland</td>
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<td>• Fee or other (financial) payment</td>
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<td>• Shareholder</td>
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<td>• Other relationship, i.e. …</td>
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</table>
General principle in all “manual” jobs - Not reserved for patient care!
PPE (Personal protective equipment)

Occupational health AND infection prevention
How to select effective PPE
How to select effective PPE

Step 1: Job Hazard Analysis
1. How does the healthcare worker contact the patient’s body?
2. How does the healthcare worker contact the environment?
3. Which bodily fluids are present where?

Step 2: Infectious disease hazard analysis
1. Source of the pathogen (body fluids or environmental reservoir)
2. Source strength (number of pathogens present or rate of shedding
3. Pathogen infectivity (dose to be received before infection is likely)
4. Severity of disease
5. Transmission route (contact, droplet, airborne); exposure surfaces

Step 3: Selection of PPE
Selected PPE must prevent pathogens from reaching exposure surfaces (port of entry), with a level of effectiveness appropriate for the severity of infection
Intubating a patient with MRSA or SARS-CoV

**Step 1: Job Hazard Analysis**
- Touching mucosa of patients’ mouth
- Touching own clothes with contaminated hands
- Coughing and ventilation creates respiratory aerosols

**Step 2: Infectious disease hazard analysis**
- Source: MRSA (skin, nares), SARS-CoV (respiratory secretions)
- Source strength: MRSA ↓, SARS-CoV ↑
- Infectivity: MRSA ↓, SARS-CoV ↑
- Severity of disease: MRSA ↓ (colonisation, infection by wounds), SARS-CoV ↑
- Transmission route: contact (MRSA, SARS-CoV), aerosols (MRSA ↓, SARS-CoV ↑)

**Step 3: Selection of PPE**
- MRSA: Surgical mask, gloves, gown
- SARS-CoV: PAPR, large gloves, gown covering wrists
Suggested questions to consider...

Donning, doffing, and changing
1. How long does it take to don and doff the PPE ensemble?
2. How easy is it to don and doff the PPE correctly?

Usability
1. Is the piece of PPE correctly sized for the wearer?
2. Can the wearer move in the PPE ensemble?
3. Does the PPE allow for necessary dexterity and tactility?
4. Does the PPE ensemble allow for unobstructed vision?
5. Does the PPE ensemble allow for the use of corrective eyewear?
6. Can the wearer hear people and equipment while wearing the PPE ensemble?
7. Can people understand verbal communication from the wearer of the PPE ensemble?
8. Can the wearer breathe comfortably while wearing the PPE?
9. How long can the PPE ensemble be worn without physiological or psychological stress?
10. How long do the pieces of the PPE ensemble maintain their integrity?
11. Is the PPE disposable?

Fit for purpose
1. Does the PPE ensemble have junctions between pieces of PPE through which pathogens may penetrate?
2. Does the PPE ensemble block the anticipated disease transmission pathway?
3. Does the PPE offer the necessary level of protection?
...and finally...

...degree of training
...work flow (working time)
...facial hair
...cost
Personal protective equipment in different situations...

...in standard precaution measures
...in additional precaution measures
  - Contact precaution measures
  - Droplet precaution measures
  - Airborne precaution measures
...in highly infectious diseases
Standard precaution measures
Assume that every person is potentially infected or colonized with an organism that could be transmitted in the healthcare setting.

Standard precaution measures apply to any care exposing the healthcare worker to blood, body fluid secretions and excretions (except sweat), non-intact skin and mucous membranes.
Standard precaution measures

- Hand hygiene
- Gloves
- Mask, eye protection
- Gown
- Patient care equipment
- Linen
- Patient placement
- Environment control
- Sharp devices
- Resuscitation

Morgan DJ *Practical Healthcare Epidemiology* 2018; Chapter 7
Hand hygiene, gloves

When hands are visibly dirty, contaminated with proteinaceous material, or visibly soiled with blood or body fluids, wash hands with a non-medicated soap and water.

Gloves: disposable, single-use, non-sterile gloves (nitrile); Change gloves during patient care if the hands will move from a contaminated body site to a clean body site.

Siegel JD Am J Infect Control 2007;35 (Suppl):65
https://www.who.int/infection-prevention/campaigns/clean-hands/5moments/en/
**Masks, eye protection**

Face shield that fully covers the front and sides of the face, a surgical mask with attached shield, or a surgical mask and goggles.

To protect mucous membranes of the eyes, nose, and mouth during procedures and patient-care activities likely to generate splashes or sprays of blood, body fluids, secretions, and/or excretions.

Siegel JD *Am J Infect Control* 2007;35 (Suppl):65
Morgan DJ *Practical Healthcare Epidemiology* 2018; Chapter 7
Gowns

Disposable, non-sterile, single-use gowns

To protect skin and prevent soiling of clothing during procedures and patient-care activities likely to generate splashes or sprays of blood, body fluids, secretions, and/or excretions

- Remove gown and perform hand hygiene before leaving the patient’s environment (or room)
- Do not reuse gowns, even for repeated contacts with the same patient
- Gowns are better than aprons

Siegel JD *Am J Infect Control* 2007;35 (Suppl):65
Morgan DJ *Practical Healthcare Epidemiology* 2018; Chapter 7
Additional precaution measures

Contact precaution measures
Gown, (gloves)

Single-patient room preferred; door may remain open; use of disposable noncritical patient-care equipment or dedicated equipment to a single patient

<table>
<thead>
<tr>
<th>Mask</th>
<th>Standard precaution measures (or when patient is vomiting)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gown</td>
<td>When entering room</td>
</tr>
<tr>
<td>Gloves</td>
<td>When entering room (^1)</td>
</tr>
</tbody>
</table>

Examples: Conjunctivitis, diarrhoea, colonisation or infection with multidrug-resistant microorganisms, skin lesions (impetigo, scabies), lice

\(^1\)gloves required for *Clostridioides difficile*, standard precaution measures may apply for other indications
KONTAKTISOLATION

Besondere Hygienemaßnahmen für Personal

Zimmer betreten

Zimmer verlassen

Besucher bitte im Stationszimmer melden
Visiteurs veuillez vous adresser au personnel
Preghiamo i visitatori di rivolgersi all’ufficio infermieristico
Visitors please report to the ward station
Additional precaution measures

Droplet precaution measures
Mask (gown)

Single-patient room preferred; door may remain open

**Mask**  Surgical mask when entering room (HCW), or leaving room (patients)

**Gown**  When entering the room (or standard precaution measures)

**Gloves**  Standard precaution measures

TRÖPFCHENISOLATION

Besondere Hygienemaßnahmen für Personal

Zimmer betreten
Chir. Maske

Zimmer verlassen

Besucher bitte im Stationszimmer melden
Visiteurs veuillez vous adresser au personnel
Preghiamo i visitatori di rivolgersi all’ufficio infermieristico
Visitors please report to the ward station
Additional precaution measures

Airborne precaution measures
Mask

Negative air-pressure, single-patient room required with air exhausted to outside or through HEPA-filters; doors must be closed

**Mask**  
N-95 mask\(^1\) (FFP2 mask) or powered air purifying respirator (PAPR) when entering room (HCW), or leaving room (patients)

**Gown**  
Standard precaution measures

**Gloves**  
Standard precaution measures

Examples: Pulmonary or laryngeal tuberculosis, measles\(^2\), Varicella\(^2\), disseminated zoster\(^2\), SARS (e.g. intubation)

\(^1\)filter 1 mm particles with an efficiency of 95% or more, can be fit-tested

\(^2\)no clear rules about wearing PPE for immune healthcare workers
AEROGENE ISOLATION
Besondere Hygienemassnahmen für Personal

Zimmer betreten

Besucher bitte im Stationszimmer melden
Visiteurs veuillez vous adresser au personnel
Preghiamo i visitatori di rivolgersi all’ufficio infermieristico
Visitors please report to the ward station

Zimmer verlassen

FFP2 Maske
Highly infectious diseases
Ebola and other haemorrhagic fevers

Single-patient room required with negative air-pressure (anteroom), air filtration

Donning and doffing of PPE...
...must be trained
...is teamwork
...takes time
...follows checklists

Have all material ready

https://youtu.be/PFbPL7_jEQY
Useful list of (precaution) measures in the care of viral haemorrhagic fevers:

<table>
<thead>
<tr>
<th>PPE for healthcare workers</th>
<th>Arenaviridae</th>
<th>Bunyaviridae</th>
<th>Filoviridae</th>
<th>Flaviviridae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Argentine hemorrhagic fever</td>
<td>Lassa fever</td>
<td>Crimean–Congo hemorrhagic fever</td>
<td>Rift Valley fever</td>
</tr>
<tr>
<td>Standard precautions</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Procedure for donning and doffing PPE with specific training for staff</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Eye protection (visor or goggles)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gloves (double)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fluid-repellent disposable coverall or gown</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Splash proof surgical mask or close fitting respiratory protective equipment (N95 or full facial protection) with aerosol-generating procedures</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fluid-repellent apron over coverall/gown</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Head cover/hood</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Closed, puncture and fluid resistant footwear</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hand hygiene</td>
<td>Alcohol-based hand rub</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Soap and water</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>0.05% chlorine solution in emergency settings (only if other methods are not available)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Systematic review on PPE for highly infectious diseases

- PPE made of **more breathable material** may not lead to more contamination than more water repellent material but may have greater user satisfaction
- **Gowns** may protect **better** against contamination than **aprons**
- The use of a **powered air-purifying respirator** may protect better than a simple ensemble of PPE without such respirator
- **Better fitting gown** around the neck, wrists and hands reduce contamination
- **Double gloving** may lead to less contamination compared to single gloving

- Following CDC recommendations for doffing may lead to less contamination compared to no guidance
- Additional **spoken instruction** may lead to fewer errors in doffing
- The use of additional **computer simulation** may lead to fewer errors in doffing
- A **video lecture** on donning PPE may lead to better skills scores
- **Face to face instruction** may reduce noncompliance with doffing
WELCOME TO REALITY
Ebola virus disease in Texas

Despite wearing more than the minimum PPE recommended by the Centers for Disease Control and Prevention (CDC) at the time, 2 nurses in Texas contracted Ebola virus disease while caring for a patient returning from West Africa with Ebola virus disease...

...likely due to a breach in the PPE protocol!
Contamination during doffing

Participants: 50 healthcare workers from 4 hospitals

1. Donning contact isolation gowns and nitrile gloves using their usual technique
2. Placement of fluorescent lotion (0.5 ml) in the palm of one hand; distribution to other hand and gown
3. Participants were asked to remove their gloves and gown in their usual manner
4. Contamination assessment with black light on skin sites (hands, forearms, neck, and face), hair, and clothing (shirt sleeves, chest, and back)
Contamination during doffing

B Gown Simulations

Skin and Clothing Contamination, %

<table>
<thead>
<tr>
<th></th>
<th>Incorrect PPE technique</th>
<th>Correct PPE technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Sites</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Hospital 1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Hospital 2</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>Hospital 3</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Hospital 4</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Tomas ME JAMA Intern Med 2015;175:1904
## Compliance with standard precautions

<table>
<thead>
<tr>
<th>Setting</th>
<th>Hand hygiene</th>
<th>Glove use</th>
<th>Gown use</th>
<th>Mask use</th>
<th>Eye-wear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golan, USA ICU</td>
<td>36%</td>
<td>62%</td>
<td>63%</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Ferguson, USA Acute care</td>
<td>61%</td>
<td>44%</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Stein, UK Acute care</td>
<td>64%; 27%*</td>
<td>57%; 11%*</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Madan, USA Trauma unit</td>
<td>ND</td>
<td>85%</td>
<td>18%</td>
<td>4%</td>
<td>47%</td>
</tr>
<tr>
<td>Chan, HKG Acute care</td>
<td>86%</td>
<td>79%</td>
<td>45%</td>
<td>46%</td>
<td>25%</td>
</tr>
</tbody>
</table>

*nurses; doctors

### Full compliance (with all measures)

- Madan, USA 0.0% (!)
- Cutter, UK 1.5% (!)

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Gammon J J Clin Nurs 2007;17:157 – Review (see for all references)
Reasons for not complying

...interference with patient care
...exposure not anticipated
...job demands
...equipment not available
Reasons for not complying

“I am clumsier when I wear gloves and risk having to repeat the procedure”

“I don't wear gloves as I cannot feel veins”

“I don't need to wear gloves when cannulating as I am skilled at what I do”

“Some procedures I learnt without personal protective equipment and I continue to perform these without”

“It is my choice to not wear gloves when cannulating as I am only putting myself at risk”

“In some workplaces it is standard practice not to follow guidelines”

“The culture of my organization allows for people not to follow standard precaution guidelines”

Reasons for complying

“I am more likely to wear personal protective equipment if they are located near patients”

“I am more careful if I know that a patient has a blood-borne pathogen”

“I am more likely to wear personal protective equipment if I see my colleagues wearing them”

“I am more likely to follow standard precautions if I am dealing with needles”

“I am more likely to follow standard precautions if I am dealing with sharp instruments”

How to improve...

Each of these studies (13) used a variety of methods in an attempt to improve compliance with standard precautions.

They all conclude that compliance does improve following a planned and structured intervention, but fail to demonstrate any permanent, longer-term compliance.

Two studies specifically note compliance soon returned to pre-intervention levels.
Summary

- Personal protective equipment is **single use** material
- PPE is **adapted to the risk of exposure**
- PPE must be both **effective** and **comfortable**
- Correct use of PPE must be **trained** *(sequence of donning and doffing)*
- **Compliance** with correct PPE-use is **low**, and **interventions** for improvement **limited** → Audits
- Highest **risk** for self-contamination is during **doffing**
- Provide **sufficient stock** of PPE at the point of care
Links

US Centers for Disease Control and Prevention: Standard Precautions for All Patient Care
https://www.cdc.gov/infectioncontrol/basics/standard-precautions.html

National Institute for Occupational Safety and Health (NIOSH): Personal protective equipment
https://www.cdc.gov/niosh/ppe/default.html

World Health Organization: Practical guideline for infection control
http://www.wpro.who.int/publications/docs/practical_guidelines_infection_control.pdf

Society for Healthcare Epidemiology of America: Guidelines stratified by topics
https://www.shea-online.org/index.php/practice-resources

Health Protection Scotland: National infection prevention and control manual
http://www.nipcm.hps.scot.nhs.uk/

Public Health England: epic3-guidelines
Loveday HP J Hosp Infect 2014;86:S1

University of Geneva Hospitals: How to enter and exit an Ebola patient room
https://youtu.be/PFbPL7_jEQY
Literature


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Thank you for your attention

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