During an influenza pandemic, the demands on healthcare workers will be extremely high. Healthcare workers will face much greater exposure to influenza than will the general public.

How should these workers be protected from influenza infection during a pandemic?

- Influenza spread by inhaling small airborne droplets produced during coughing, sneezing, speaking and breathing.
- Or it is only spread by direct contact and by large visible drops?
- Do healthcare workers need to wear respiratory protection during a pandemic?
- If so, what kind? When does it need to be worn?

**Respiratory Protection and Influenza-laden Cough**

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National Institute for Occupational Safety and Health

**Our Approach: A simulated medical examination room**

- NIOSH has constructed a test chamber to simulate a coughing patient in an examination room with a healthcare worker.
- The room includes a coughing simulator, a breathing simulator, airborne particle (aerosol) counters and aerosol samplers to collect particles for analysis.
- The coughing simulator can cough aerosols containing influenza virus into the room.
- The breathing simulator can be outfitted with different types of personal protective equipment (PPE) such as surgical masks, filtering facepiece respirators, powered air-purifying respirators (PAPRs) and face shields.
- The breathing simulator can be moved to different locations in the room.
- The room temperature, humidity and ventilation rate can be controlled.
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- The breathing simulator can be moved to different locations in the room.
- The room temperature, humidity and ventilation rate can be controlled.
- The room has an HEPA filtration system to clear particles from the air and a germicidal UV light to disinfect the air.

**Results: Protection from Airborne Influenza Virus**

- This plot shows the flow rate over time of an experimental cough.
- This flow profile is based on measurements of coughs from 17 healthy adult subjects in a previous study at NIOSH (WT Goldsmith et al. A system for analyzing aerosols produced by humans during respiratory maneuvers. Ann Biomed Eng 29 Sup 1: S141, 2001).
- The experimental cough has a 2.1 l/min volume with a peak flow of 4.85 liters/sec and a mean flow of 3.94 liters/sec.
- The breathing simulator has a sinusoidal flow rate of 32 liters/min for most experiments. 85 liters/min is used for some experiments to study the effect of breathing rate.

**Results: How cough aerosol particles spread in a medical examination room**

- This plot shows the percentage of particles of different sizes that reach the mouth while the simulated worker is wearing typical surgical masks (KCS 470 and PRS), and typical medical N95 respirators (3MN1870 and KCN468).
- For these experiments, the masks and respirators were sealed to the breathing simulator head form.
- Masks and respirators block large particles most effectively, and their filtration efficiency decreases as particle size decreases down to 0.3 µm.
- Even when it is sealed to the face, a surgical mask still allows about 14% of the smallest airborne particles to be inhaled.
- In practice, face seal leaks around the edge of a surgical mask lead to much worse filtration performance.
- On the other hand, an N95 respirator provides excellent protection if it forms an adequate seal with the face.

**Results: Masks & N95 respirators vs. particle size**

- This plot shows the percentage of particles of different sizes that reach the mouth while the simulated worker is wearing typical surgical masks (KCS 470 and PRS), and typical medical N95 respirators (3MN1870 and KCN468).
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- In practice, face seal leaks around the edge of a surgical mask lead to much worse filtration performance.
- On the other hand, an N95 respirator provides excellent protection if it forms an adequate seal with the face.

- This plot shows the distribution of airborne influenza virus from a simple cough at different locations in the exam room over time.
- In the first few minutes after a cough, the cough particles travel across the room in a concentrated plume, causing a sharp spike in exposure for anyone directly across from the patient.
- However, within about 5 minutes, the cough particles spread throughout the room, and everyone inside is exposed to them regardless of their location.

For more information, contact Dr. William G. Lindsley, wlindsley@cdc.gov.

**Our Publications**

- Lindsley, W, D Schmechel, A McHale, T Chen, P Driscoll, N Khakoo, BJ Meade, O Lander, S Davis, RE Thewlis, KA Davis, PRS no yes