Occupational Influenza Transmission: An Overview of Past and Ongoing Projects

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Aims

Transmission of influenza virus: focus on aerosol transmission
How to protect healthcare workers exposed to influenza virus

Disclaimer: The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

Key Issues Addressed

Early Clinical Studies

1. Airborne Influenza Virus in Healthcare Facilities

Laboratory Studies

Construction of a Simulated Patient Exam Room to study:

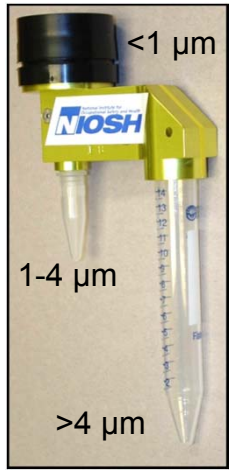
2. Infectivity of Virus in Aerosols
3. Effectiveness of Respirators and Masks
4. Effectiveness of Face Shield
5. Effect of humidity on Virus Infectivity

Latest Clinical Studies

6. Infectious Influenza Virus Emitted in Coughs
7. Identification of Aerosol Generating Medical Procedures
8. “Evaluating Modes of Influenza Transmission (EMIT)

1. Airborne Influenza Virus in Healthcare Facilities

Goal: Determine amount and size of airborne particles containing influenza A virus (qPCR only).



Ruby Hospital Emergency Dept

4 days of 2008 flu season;
3-5 flu patients/day

74 stationary samplers (2 waiting room, 2 exam rooms, reception area, triage room) + 21personal samplers.

Results:

- Virus detected in all rooms except the exam rooms (~15 virus/L room air).
- 46% virus (>4 µm), 49% virus (1-4 µm), 4% virus (<1 µm).
- Virus detected in 3 personal samplers.

Blachere et al (2009) Clin Inf Dis

WVU Urgent Care Clinic

11 days of 2009 flu season;
1-4 flu patients/day

264 stationary samplers (1 waiting room, 6 exam rooms, 2 procedure rooms) + 21 personal samplers.

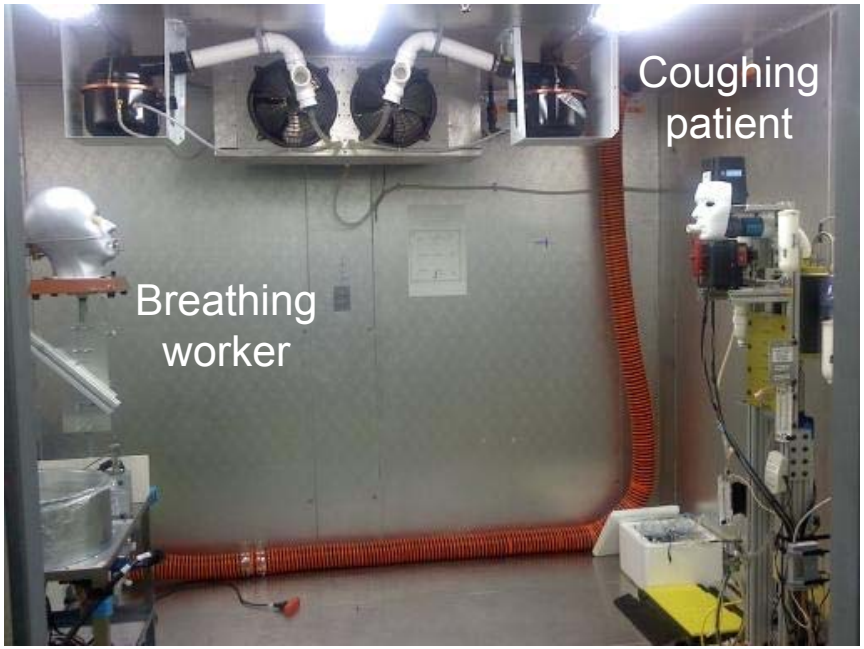
Results:

- Virus detected in all rooms, highest in exam rooms.
- 46% virus (>4 µm), 42% virus (1-4 µm), 11% virus (<1 µm).
- Virus detected in 4 personal samplers.

Lindsley et al (2010) Clin Inf Dis

Construction of a Simulated Patient Exam Room:
2. Infectivity of Virus in Aerosols

Room Description:
Programmable coughing and breathing simulators
NIOSH samplers collect from mouth and room
Can assess respirator, mask or face shield
Can cough broad range particle sizes
Room temp and humidity controllable



Results:

- Coughed 0.4 μm KCl particles impact directly on breather.
- Within minutes aerosols spread throughout room.
- N95 blocks >99% KCl aerosol particles; mask blocks 86%.

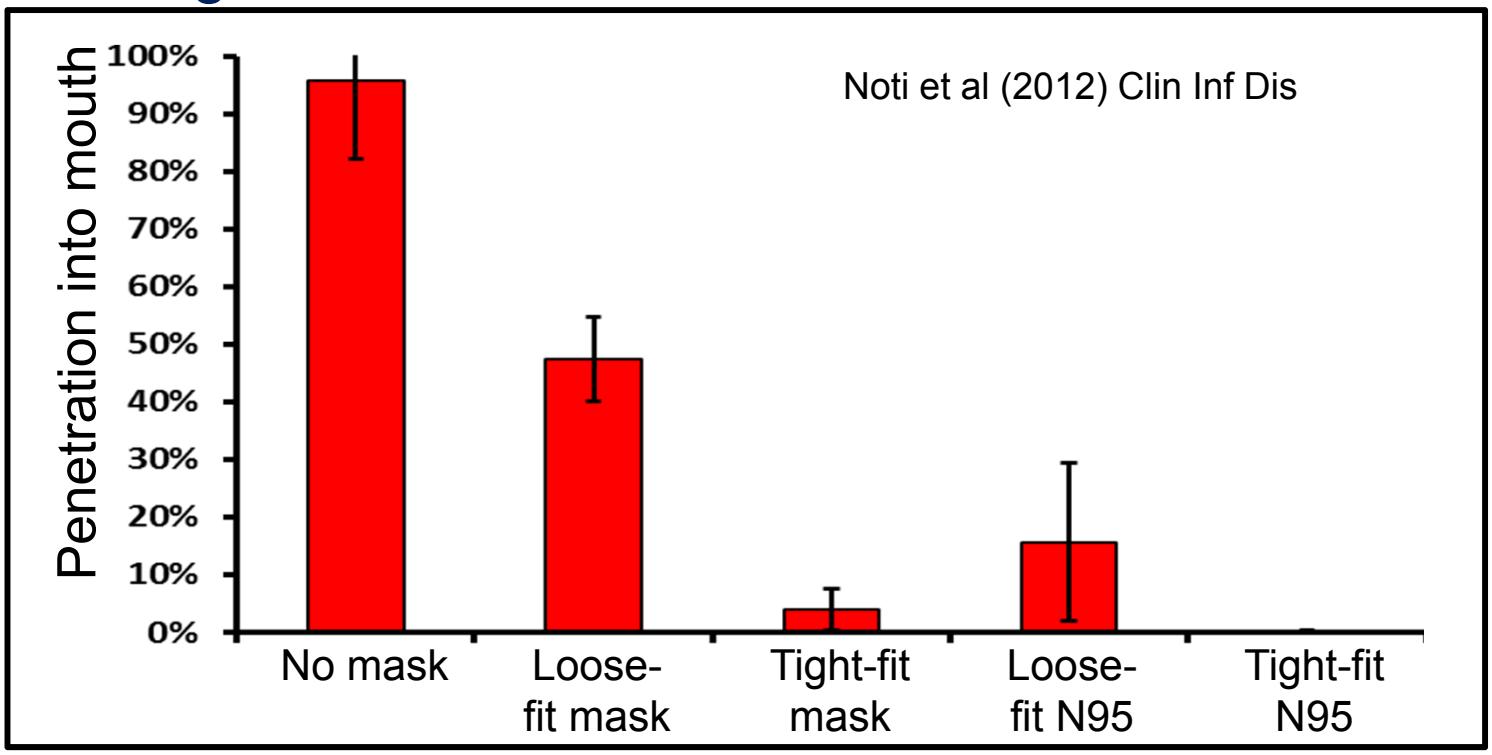
Cao et al (2011) J Environ Monit
Lindsley, King et al (2012) J Occup Environ Hyg

Results:

- Coughed infectious influenza virus collected in all aerosol fractions (<1μm, 1-4 μm, >4 μm).
- Virus in all fractions retained ability to infect MDCK cells.
- Infectivity detected up to 5 h after coughing.
- Infectivity drops over 5 h collection time.

Noti et al (2012) Clin Inf Dis
Noti et al (2013) PLOS ONE

3. Effectiveness of Respirators and Masks: Preventing Inhalation of Infectious Airborne Influenza Virus

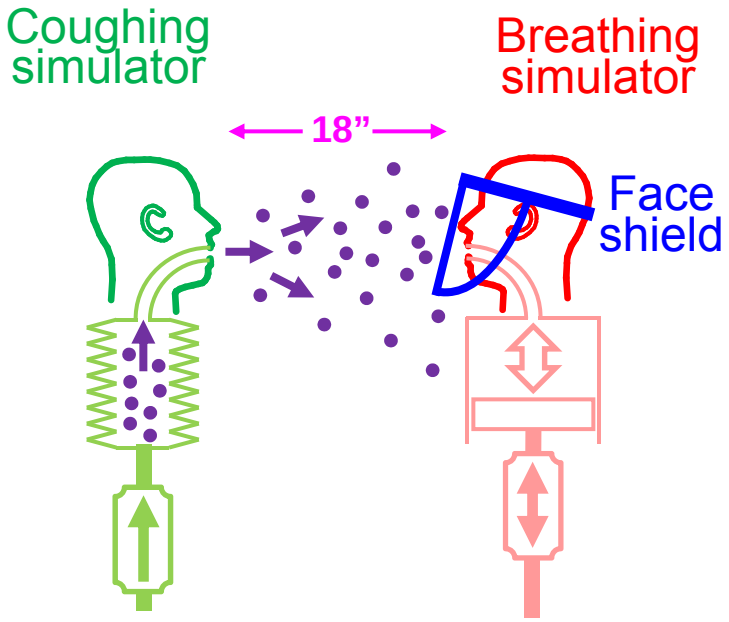


Infectious virus was coughed into simulated exam room.

Results:

- Loose-fit mask (as normally worn by workers) blocks about 50% .
- Loose-fit N95 (poorly fitted) blocks about 80%.
- Tight-fit N95 (properly fitted) blocks >99% of infectious influenza virus.
- Note: Tight-fit (sealed with caulk) mask blocks about 95%, potential for new product- ”BREATHE”

4. Effectiveness of Face Shield: Reduced Exposure to Infectious Influenza Virus



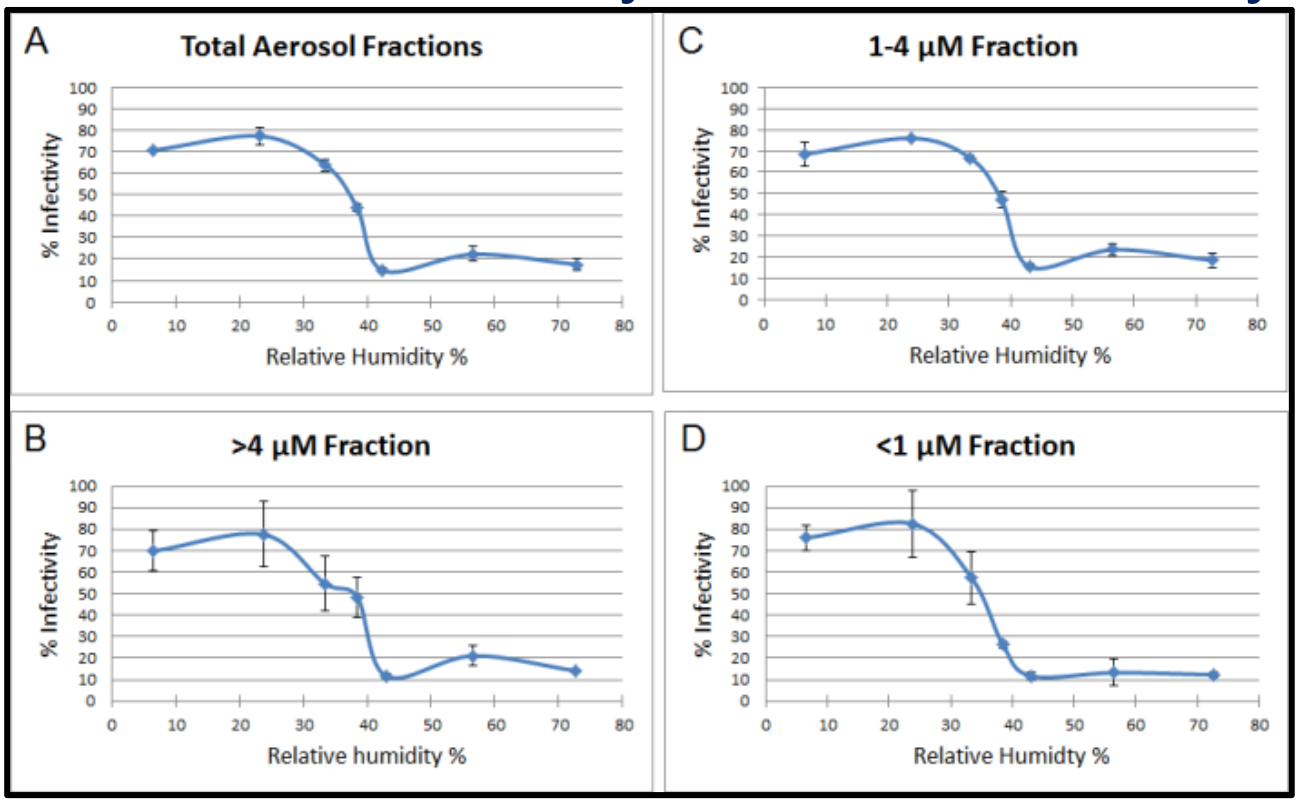
Coughed broader size range of influenza particles (0.1 µm to 100 µm).

Results:

- Face shield blocked 95% of the infectious virus from reaching the mouth.
- Some smaller viral particles can circumvent the face shield.
- Significantly more smaller particles reach the mouth as distance between cougher and breather gets larger.

Lindsley et al. Manuscript in preparation

5. Effect of Humidity on Virus Infectivity



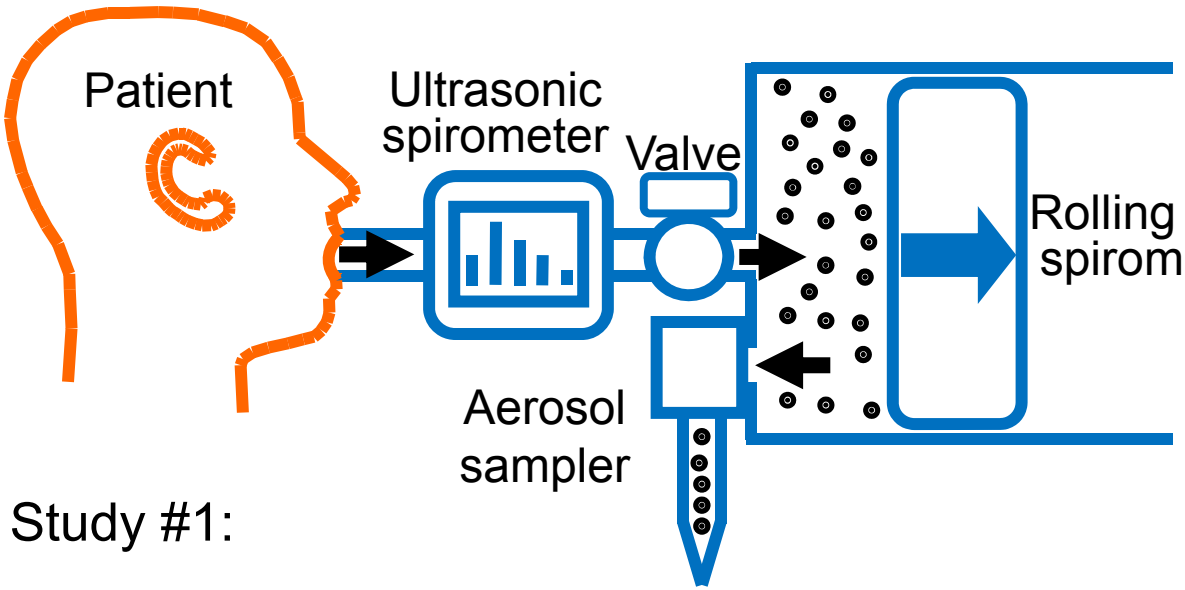
Infectious virus was coughed into the simulated exam room. The relative humidity in the simulated exam room was varied over 7-73% at 20^{O}C.

Results:

- Similar losses of infectivity with increasing humidity regardless of aerosol fraction size.
- Significant loss of infectivity occurs within 0-15 min after coughing.

Noti et al (2013) PLOS ONE

6. Infectious Influenza Virus Emitted in Coughs



Study #1:

- Patients cough out larger aerosol volumes when infected with influenza virus.

Lindsley, Pearce et al (2012) J Occup Environ Hyg

Study #2:

- Influenza virus was detected by PCR in coughs from 38 of 47 patients (81%).
- 65% of the virus detected by PCR was in the respirable (≤4 μm) size fraction.
- Infectious virus was cultured from the coughs of 2 of 21 patients.

Questions raised: Why only 2 patients? Enough for an infectious dose?

Lindsley et al (2010) PLOS ONE

7. Identification of Aerosol Generating Medical Procedures

- Collaborative project with David Weissman, Division of Respiratory Disease Studies (DRDS) at NIOSH and the West Virginia University School of Medicine.

- Procedures including bronchoscopy, suctioning, ventilation, and intubation have the potential for producing aerosols.

- Room air will be evaluated for the size and number of aerosol particles and for the presence of infectious influenza virus.

- Prior to influenza season, genomic markers were used as surrogate markers in aerosols but with limited success.

Recent Findings:

- Analyzed aerosol samples collected from 3 ventilated patients with severe influenza infections.
  - Collected aerosols were PCR positive for influenza virus.
  - Infectivity not assessed.

8. Evaluating Modes of Influenza Transmission using a Human Challenge Model (EMIT)

- Funded by CDC
  - Principle investigator: Jonathan Nguyen-Van-Tam, University of Nottingham
- Goal: To assess the relative contribution of influenza transmission by droplet spray, contact, and aerosol.
- Recipients will be exposed to donor volunteers experimentally infected with H3N2.
- Recipients randomized to either a control arm (no intervention- allowing all modes of transmission) or an intervention arm (face shield and hand hygiene – allowing only transmission by aerosol).
- Air samples will be collected with NIOSH samplers and processed for influenza (qPCR and VPA) by HELD (3 EMITs scheduled from Feb-April 2013).

Future Directions

- Explore aerosol transmission through the use of H9N2 viruses. Collaboration with Daniel Perez, Univ. of MD.
- Explore the role of temperature and **absolute** humidity in influenza virus transmission. Collaboration with Jeffrey Shaman, School of Public Health Columbia University.
- Begin studies of “Ultraviolet Germicidal Irradiation (UVGI) Systems for Respirator Reuse and Ambulance Disinfection during a Pandemic” Steve Martin (PI) NIOSH DRDS.
  - Funded by FY13 Fiscal Allocation Process: CDC Public Health Preparedness and Response (PHPR).
- Improve the detection of infectious influenza virus via development of luciferase-reporter based methodologies. Collaboration with Reuben Donis, Influenza Division, NCIRD.