Modes of Transmission of Seasonal Human Influenza Viruses

Allison McGeer, MSc, MD, FRCPC
Professor, Dalla Lana School of Public Health
University of Toronto
Director Infection Control
Infectious Disease Consultant
Mount Sinai Hospital
amcgeer@mtsinai.on.ca

Empiric observations about influenza transmission:
- 8-30% of the world's population is infected annually – with newly evolved clades
- In temperate climates, influenza is seasonal
- In households, secondary attack rate is ~15%
- In closed institutions, outbreaks can be explosive
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Influenza A outbreak
Nursing Home, Ontario, 2005

48% in 4 days (<3 generations)
When are persons infectious?

- Systematic review, 2005
- 2012 citations reviewed
- 32 eligible for assessment
  - 8 virus survival
  - 15 experimental
  - 9 outbreak reports
Evidence for contact spread

- Humans can be infected by nasal drops
- Influenza virus survives on hands for 5 minutes, on cloth/paper/tissue for up to 12 hours, and on non-porous surfaces for up to 48 hours
- Improved hand hygiene reduces the risk of respiratory illness and absenteeism due to respiratory illness by ~30%

BMC Public Health 2004;4:50
Evidence for aerosol spread

- Humans can be infected by inhalation of aerosols

Factors affecting viable influenza in aerosols

- Concentration of virus in respiratory secretions
- Person to person variability in particle distribution
- Temperature and humidity
- Breathing/talking/coughing/sneezing

Fabian PLoS ONE 2008;3(7)e2691

Size distribution of droplet formed by talking, coughing, and sneezing

(Kowalski & Bahnfieth, 1998)
Expulsion of infectious material: Effect of Particle Size

- Diameter greater than 100 µm (Ballistic particles)
  - predominantly affected by gravitational forces

Inhalation: Inhalable size particles account for <10% of volume of a cough

- Nasopharyngeal-sized particles
  - 20-100 µm in diameter
- Tracheobronchial-sized particles
  - 10-20 µm in diameter
- Alveolar-sized particles (pulmonary)
  - ≤10 µm in diameter
Droplet exposure

- How much infection is by
  - Direct deposition onto facial mucous membranes? (eye vs. nose vs mouth)
  - Deposition onto hands, with transfer to face?
  - Inhalation?

What is the evidence that influenza can be spread by long distance aerosols?

- Transmission from ferret to ferret occurs in ferrets separated by straight, U or S shaped ducts (Andrewes, Br. J Exp Pathol 1941;22:91)
- Documented in mice (Shulman, Am J Pub Health 1968;58:2092)
- TB patients housed in building with ceiling UV radiation less likely to get influenza than those in building without (Riley Am Rev Tuberc 1957;75:420)
- Increased ventilation resulted in reduced influenza (Wan Aerosol Science Tech 2007;41:244)
- Alaska Airlines outbreak (Moser, 1979)
Epidemic of influenza-like illness among passengers and crew exposed to an acutely ill passenger with influenza A

(Moser Am J Epidem 1979;110:1)

Number of cases

4.2 hours on ground,
2-3 without ventilation

SEAT OCCUPIED BY INDEX CASE

CARGO AREA

COMPARTMENT BULKHEAD

LAVATORY

COAT CLOSET

BUFFET
Pending studies of transmission

- Booy (Australia): control vs. mask vs. respirator
- Leung (HK): control vs. HH vs. HH + mask
- Monto (US): control vs masks vs HH +mask
- Larson (US): control vs HH vs HH + mask

Questions about H2H influenza transmission

- What is the relative contribution of contact vs. aerosol transmission?
- What patients are responsible for transmission?
  - Pre-symptomatic? Asymptomatic?
- How important is heterogeneity in transmission from source patients?
- Does long distance aerosol transmission contribute?