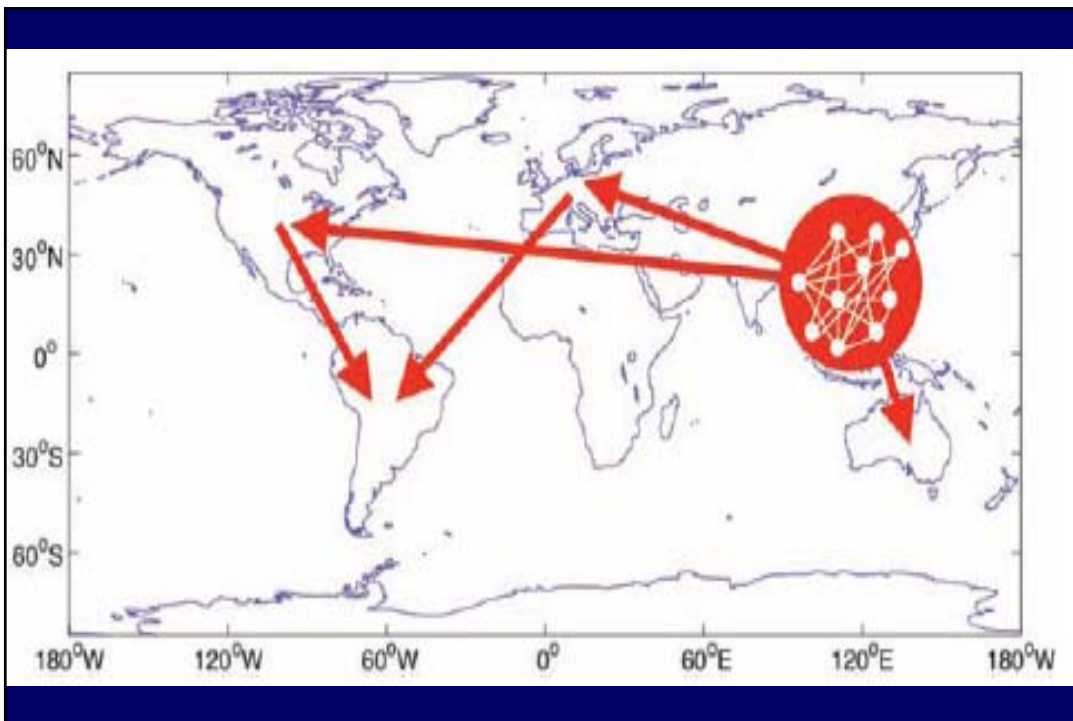
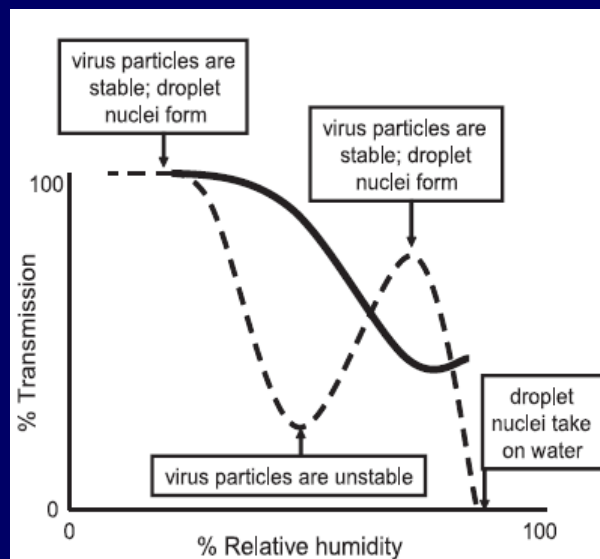
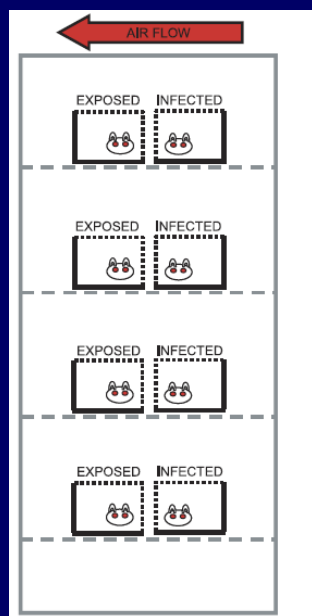
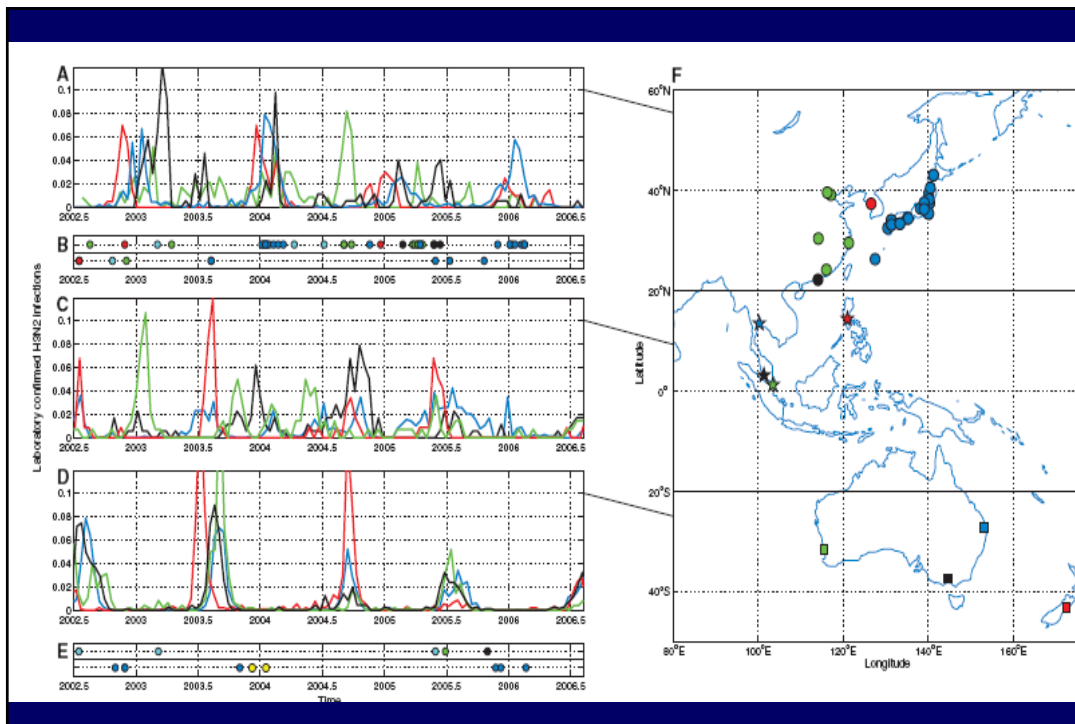


## Modes of Transmission of Seasonal Human Influenza Viruses

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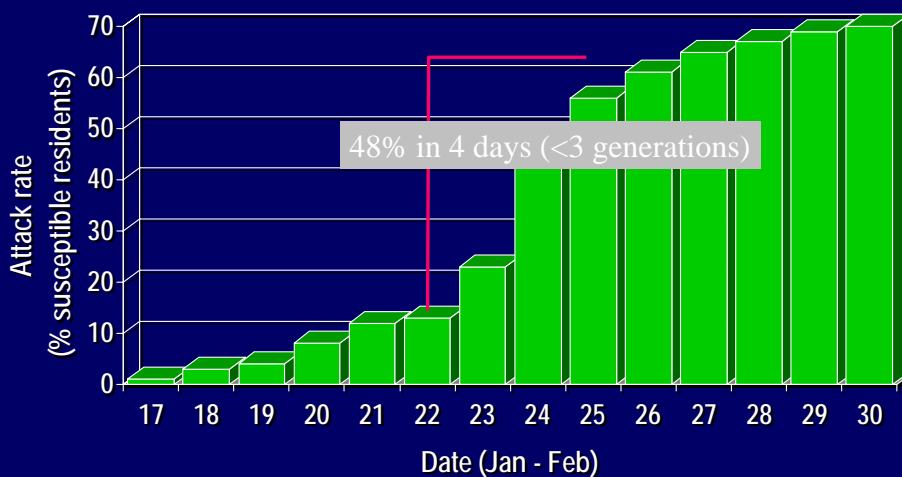


Lowen PLoS Pathogens 2007;3(10):e151

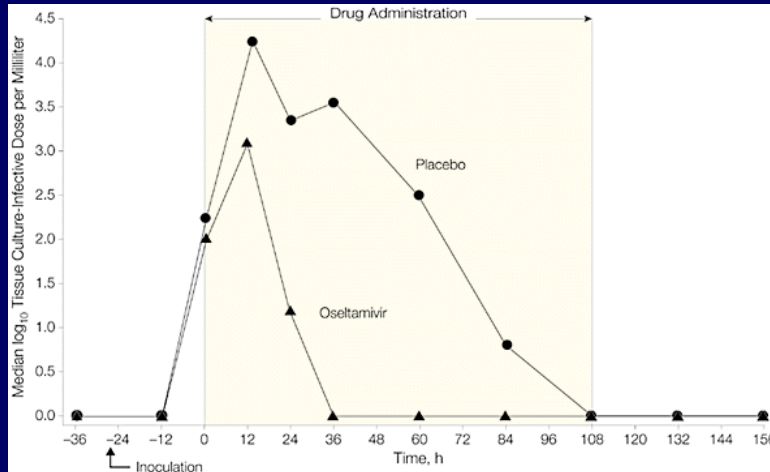
## Empiric observations about influenza transmission

- 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

## Influenza A outbreak Nursing Home, Ontario, 2005



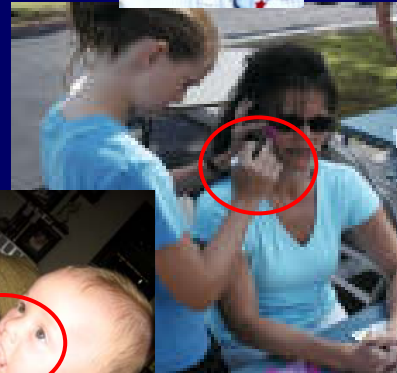
## When are persons infectious?



## Level of evidence

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

# CONTACT



## 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%

Am J Prev Med 2001;21:79-83 AJIC 2003;31:364-70  
BMC Public Health 2004;4:50

## Evidence for aerosol spread

- Humans can be infected by inhalation of aerosols

## DROPLET/AEROSOL

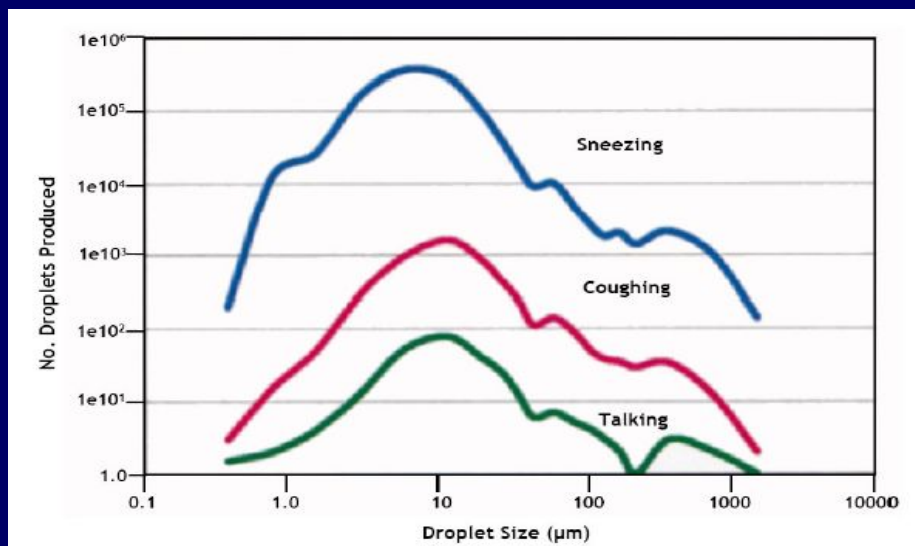


Kowalski and Bahnfleth, 1998; Tang JW et al. *J Hosp Infect* 2006

## 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 & Bahnfleth, 1998)

## Expulsion of infectious material: Effect of Particle Size

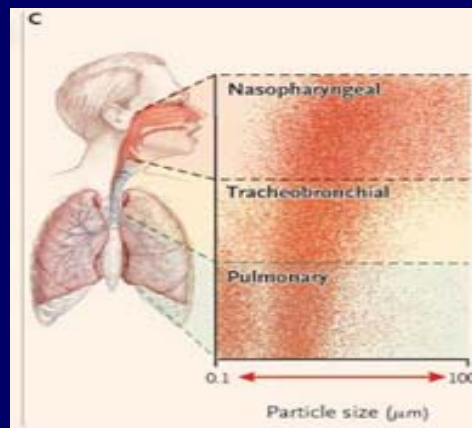
- Diameter greater than 100  $\mu\text{m}$   
(Ballistic particles)
  - predominantly affected by gravitational forces



Kowalski and Bahnfleth, 1998; Tang JW et al. *J Hosp Infect* 2006

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

- Nasopharyngeal-sized particles
  - 20-100  $\mu\text{m}$  in diameter
- Tracheobronchial-sized particles
  - 10 -20  $\mu\text{m}$  in diameter
- Alveolar-sized particles (pulmonary)
  - $\leq 10$   $\mu\text{m}$  in diameter



Roy CJ *NEJM* 2004



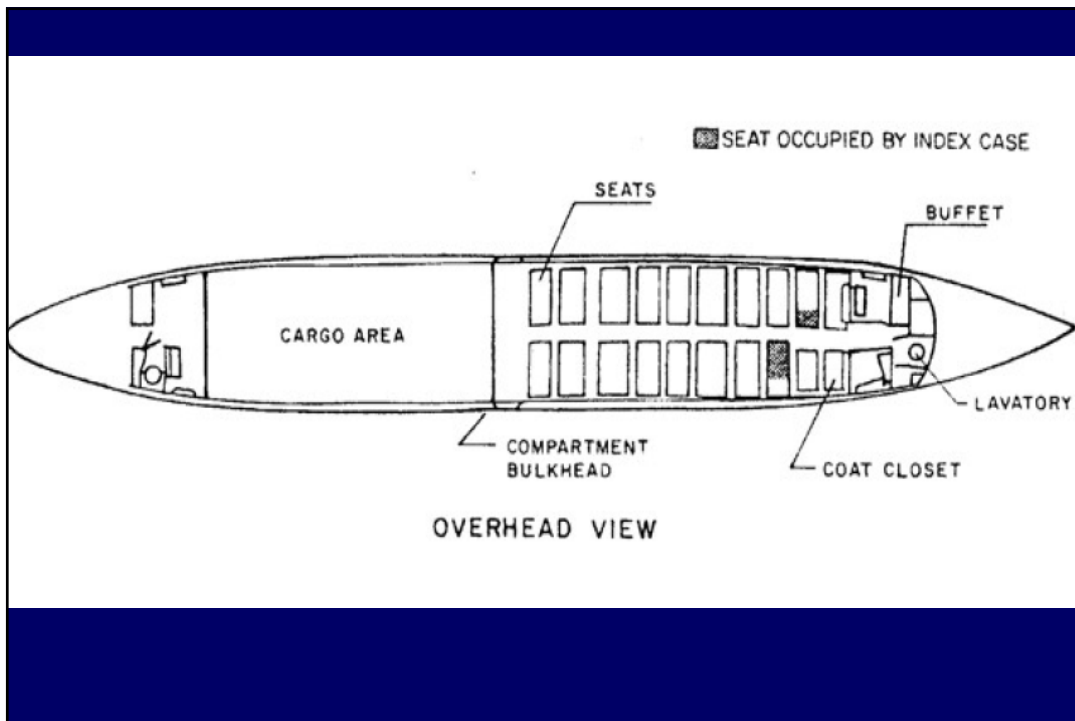
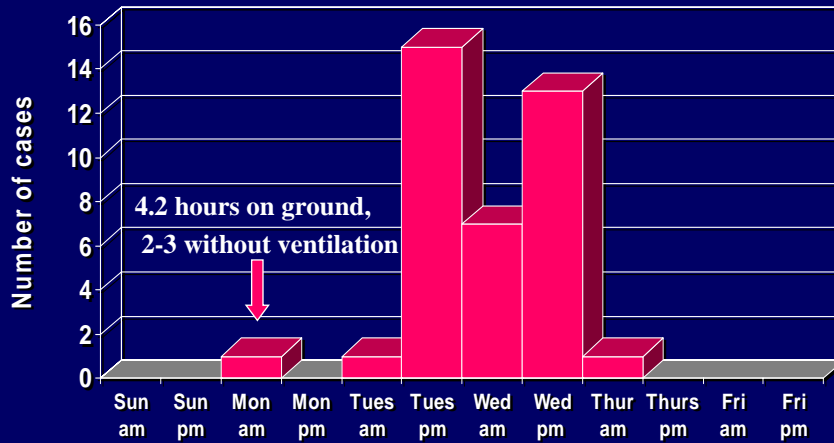
## Droplet exposure

- 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)**



## 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?