How ambient humidity may affect the transmission of viral infectious diseases

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Virus Transmission v. Ambient Humidity

- Many viral diseases could be airborne
  - Influenza
  - SARS
  - Common cold (rhinovirus, etc.)
  - Measles
  - Foot and mouth disease

- Humidity affects viral transmission
  - Bioaerosol size, deposition
  - **Virus survival**

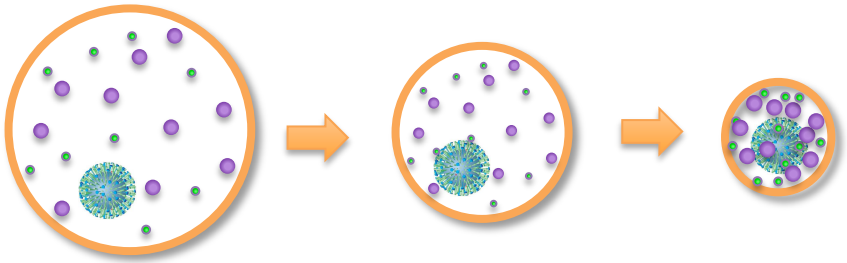
Mechanisms Unclear

- *Need a better understanding*
  - Better prevention
  - Identify experimental confounders

http://kbosweeney.files.wordpress.com/2010/10/cold.jpg

Why would a virus within an aerosol be affected by ambient humidity?

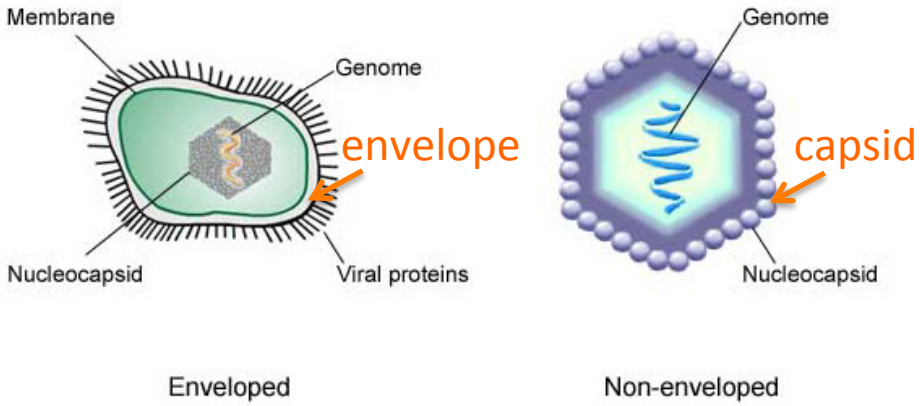
- Relative humidity (RH) v. Evaporation



$$RH = \frac{p_d}{p_{sat}} = \exp\left(\frac{4M_w\sigma_w}{RT\rho_w d}\right)\exp\left(-\frac{6n_s v_w}{\pi d^3}\right)$$

(Köhler theory)

- Enveloped v. non-enveloped viruses
  - Lipid membrane: hydrophobic
  - Surface proteins
  - Capsid structure
- Enveloped viruses: lower RH
- Non-enveloped: higher RH



http://www.elu.sgul.ac.uk/rehash/guest/scorm/343/package/content/nuclear_envelope.htm

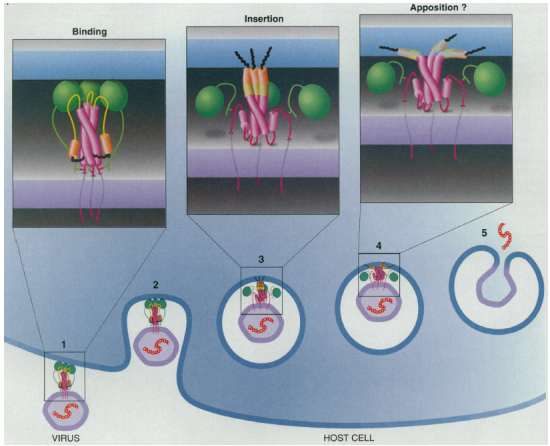
How RH affects a virus within an aerosol?

- Remove structural water *-> damage* the capsid
  (non-enveloped)

- Change in surface area (surface inactivation)
  - Protein unfolding *-> damage* the envelope

- Change in solute concentration (toxicity)
  - Ions bind to envelope *-> damage* envelope
  - Retain structural water *-> protect* capsid (non-enveloped)

- Change in pH (conformational changes)
  - Low pH -> unfolding *-> damage*
  - Depends on sensitivity to pH

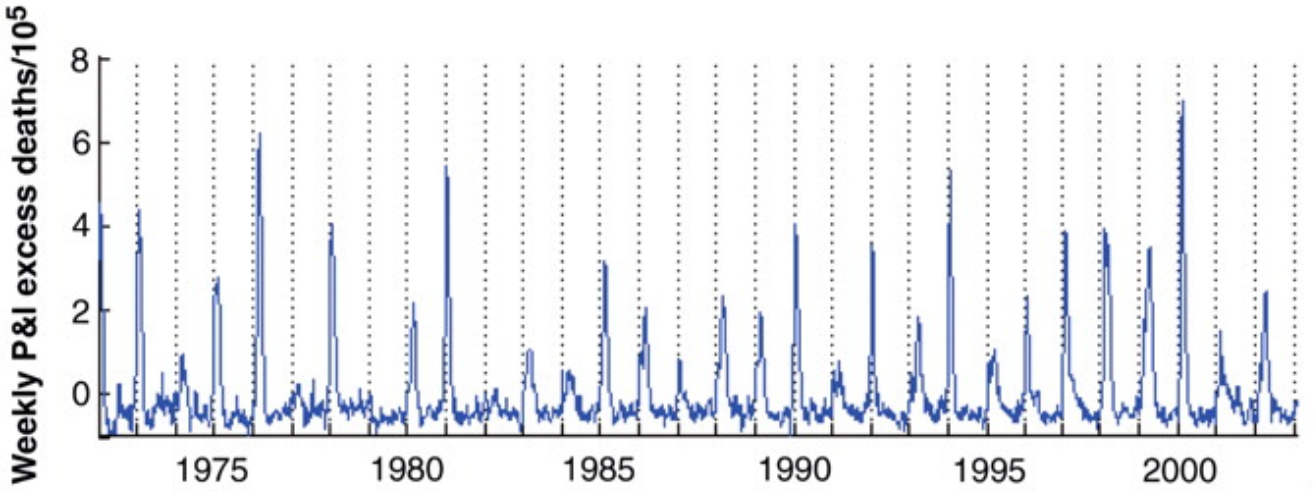


Influenza virus enters a cell by endocytosis at pH <5

Yang and Marr 2012 *AEM;* Carr and Kim 1994 *Science*

RH may affect distribution patterns of diseases (case study: influenza)

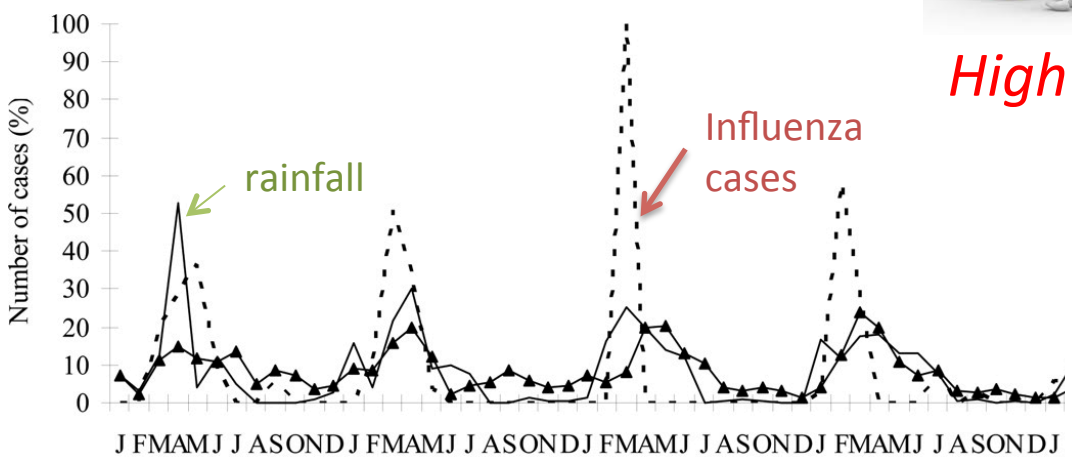
- Influenza spreads in winter in temperate regions



Low RH

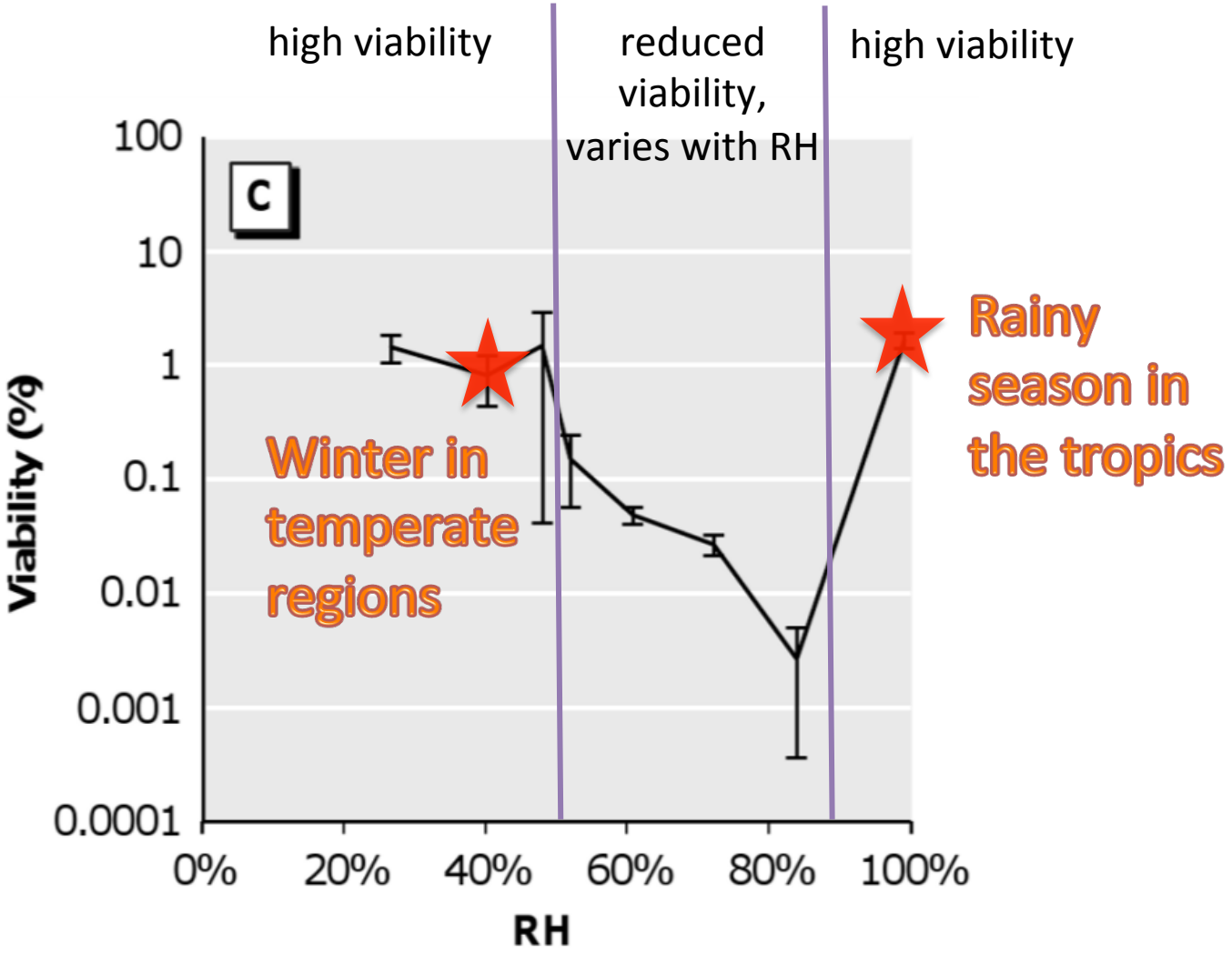
High RH

- In rainy seasons in some tropical regions



Viboud et al., 2006, *Science*; Moura et al.,2009, *Am J Trop Med Hyg*

Influenza Viability v. RH in Mucus

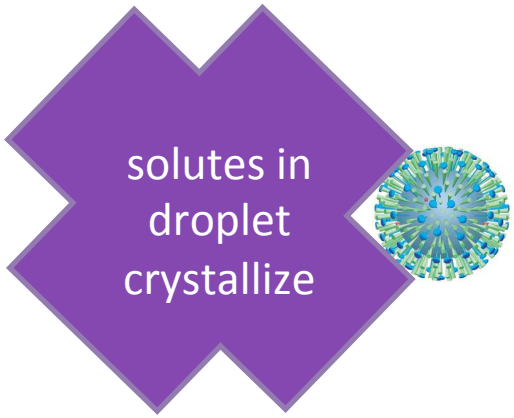


Yang et al., 2012, *PLoS One*

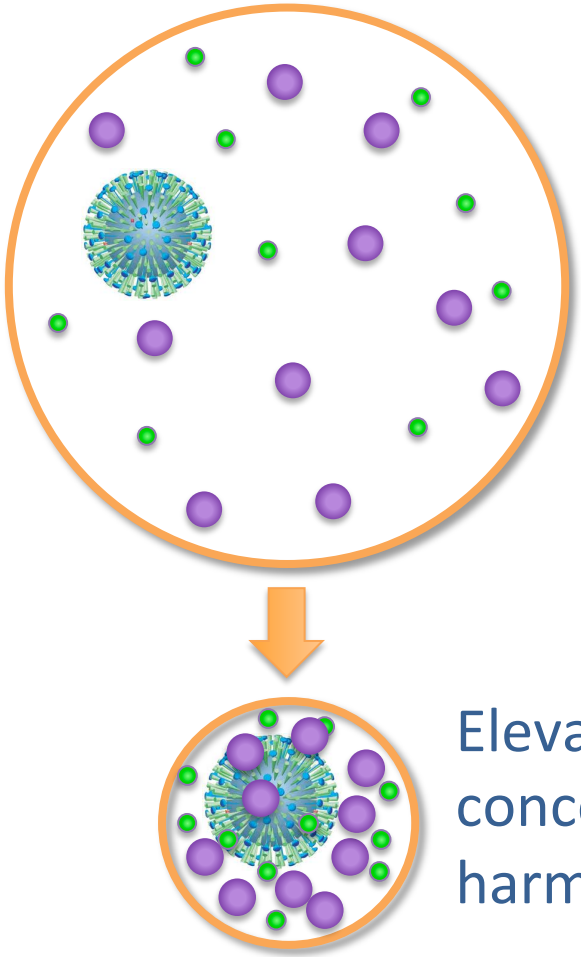
Viability and Three RH Regimes

Low RH (<50%)

Efflorescence occurs ⇒ solutes cannot harm virus ⇒ viability is maintained



Medium RH



Very high RH

Minimal evaporation ⇒ physiological conditions are maintained in droplet ⇒ viability is maintained

Elevated solute concentrations may harm virus

Yang et al., 2012, *PLoS One;* 2012 *AEM*

Conclusions

- Humidity could affect the transmission of viral diseases
  - Water activity
  - Surface inactivation
  - Salt toxicity
  - Conformational change
- The relationship between RH & viability may modulate the distribution of viral infectious diseases
- Better understanding, better prevention

THANK YOU!

QUESTION?

Sources:

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