Climate Change & Respiratory Infections

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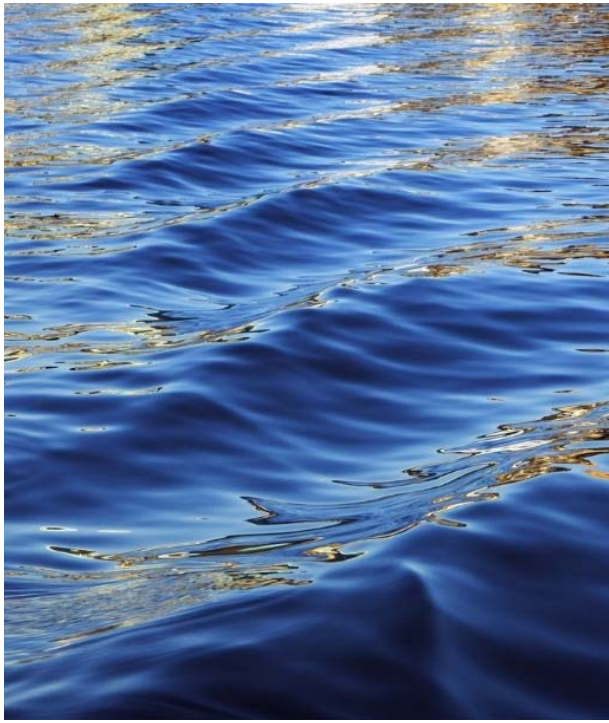


Presentation Outline

- Recognition of an on-going global climate change
- Climate change and infectious diseases
- Connecting the dots
- The Case of Hong Kong
- Conclusions

Recognition of an on-going global climate change

- Climate change :

  long-term statistical shifts of the weather

- There is a general recognition of an on-going global climate change
- According to the European Environment Agency:
  - the global average surface temperature has increased by 0.74 °C in the 20th century
  - global sea level has been rising 1.8 mm per year since 1961
  - Arctic sea ice has been shrinking by 2.7% per decade
  - Mountain glaciers are contracting
  - Ocean water becomes more acidic
  - Extreme weather events occur more often
- The Intergovernmental Panel on Climate Change (IPCC) :
  - An average temperature rise of 1.5–5.8 °C across the globe during the 21st century

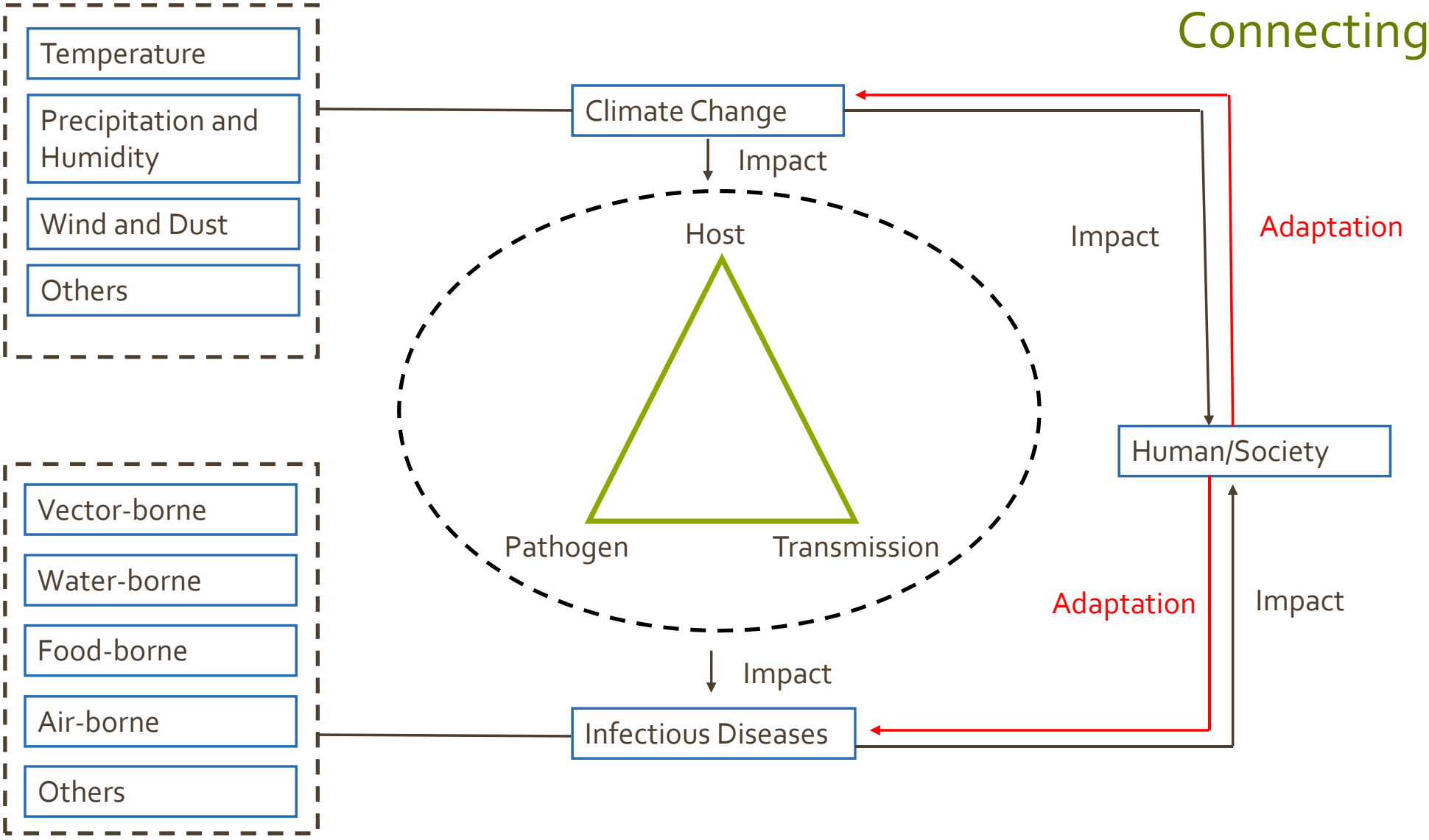
1. Climate Change 2007: Impacts, Adaptation and Vulnerability
2. Climate Change 2001: Synthesis Report
3. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation

Climate change and infectious diseases

- Climate change can affect human health → Infectious diseases
- Three components are essential for most infectious diseases:
  - An agent (or pathogen)
  - A host (or vector)
  - Transmission environment
- Appropriate climate and weather conditions are necessary for the survival of disease pathogens, vectors, and hosts.
- Changes in climate or weather conditions may impact infectious diseases
- Studies have found that long-term climate warming tends to favor the geographic expansion of several infectious diseases
- Extreme weather events may help create the opportunities for more clustered disease
- Climate conditions constrain the geographic and seasonal distributions of infectious diseases, and weather affects the timing and intensity of disease outbreaks

1. P.R. Epstein (2001) Climate change and emerging infectious diseases
2. R.S. Ostfeld, J.L. Brunner (2015) Climate change and Ixodes tick-borne diseases of humans
3. X.X. Wu (2014) Impact of global change on transmission of human infectious diseas

Connecting dots…

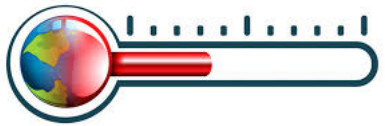


1. Wu X. (2016) Impact of climate change on human infectious diseases: Empirical evidence and human adaptation

Rising temperature reduces the incubation time

- The impact of climate change on pathogens can be direct or indirect
- Quantity, geographic and seasonal distributions of pathogens may change

1. Pathogen needs a certain temperature range to survive and develop
2. Rising temperature can influence the extrinsic incubation period (EIP) of pathogens
3. Extended periods of hot weather can raise the average temperature of water bodies and food environment, which may provide an agreeable environment for microorganism
4. Rising temperature may limit the proliferation of a pathogen through favoring its competitors.



1. P.S. Mellor (2000) Climatic and geographic influences on arboviral infections and vectors
2. H.Y. Tian (2015). Avian influenza H5N1 viral and bird migration networks in Asia
3. H.Y. Tian (2015). hanges in rodent abundance and weather conditions potentially drive Hemorrhagic Fever with Renal Syndrome outbreaks in Xi'an, China, 2005–2012

Rising temperature expanse geographical shift of diseases

- Temperature affects the spatial–temporal distribution of disease vectors
- As temperature continues to rise, the vectors in low-latitude regions may find new habitats in mid- or high-latitude regions and in areas of high altitude, leading to geographical expansion or shift of diseases
- However, temperature change may as well restrict the distribution of some disease vectors

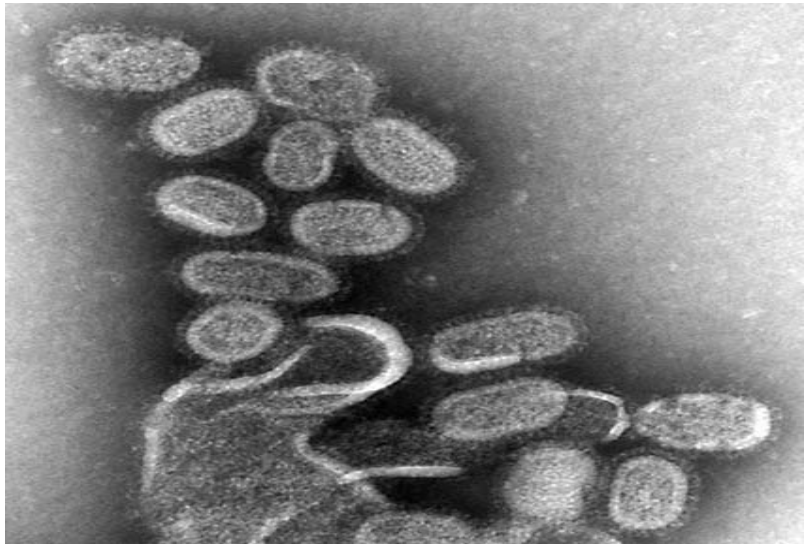
1. C.D. Harvell (2002). Climate warming and disease risks for terrestrial and marine biota
2. Y.B. Zhou (2010). Effects of low temperature on the schistosome-transmitting snail Oncomelania hupensis and the implications of global climate change

Rising temperature alter transmission of diseases

- Depending on the transmission route, disease transmission can be direct or indirect
- Direct transmission refers to the transmission of a disease from one person to another through droplet contact, direct physical contact, indirect physical contact, air-borne transmission, or fecal–oral transmission
- Indirect transmission refers to the transmission of a disease to humans via another organism, a vector, or an intermediate host
- Temperature change alone, or together with other variable changes such as rainfall, may alter the transmission of diseases

1. M.J. Bouma (2003) Methodological problems and amendments to demonstrate effects of temperature on the epidemiology of malaria. A new perspective on the highland epidemics in Madagascar, 1972–1989

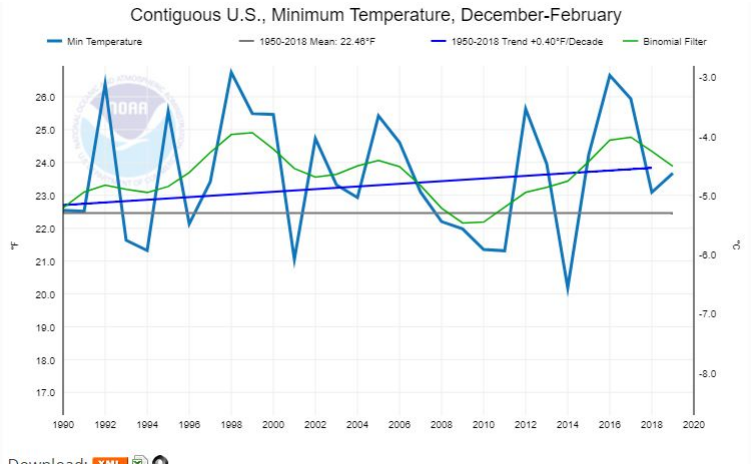
Influenza A virus subtype H1N1

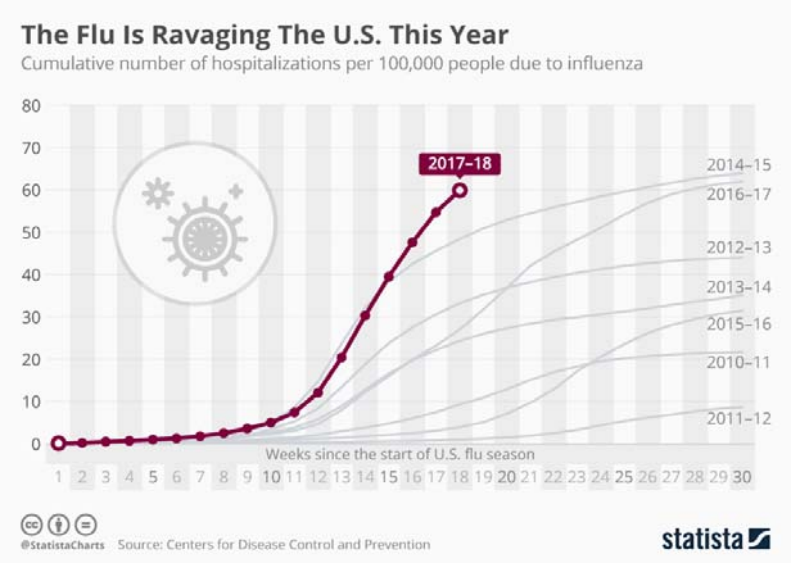


Transmission electron micrograph of AH1N1[1,2]

- Orthomyxovirus that contains the glycoproteins haemagglutinin and neuraminidase
- Infects pigs, birds, and humans
- Pathology
  - ❑Pneumonia
- Symptoms
  - ❑Cough
  - ❑Fever
  - ❑Sore throat
  - ❑Stuffy or runny nose
  - ❑Body aches
  - ❑Headache
  - ❑Chills
  - ❑Fatigue
- Diagnosis
  - ❑Nasal swabs
- Treatment
  - ❑Antiviral drugs

1. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)
2. 2. The Public Health Agency of Canada





Increasing temperature reduces incubation period

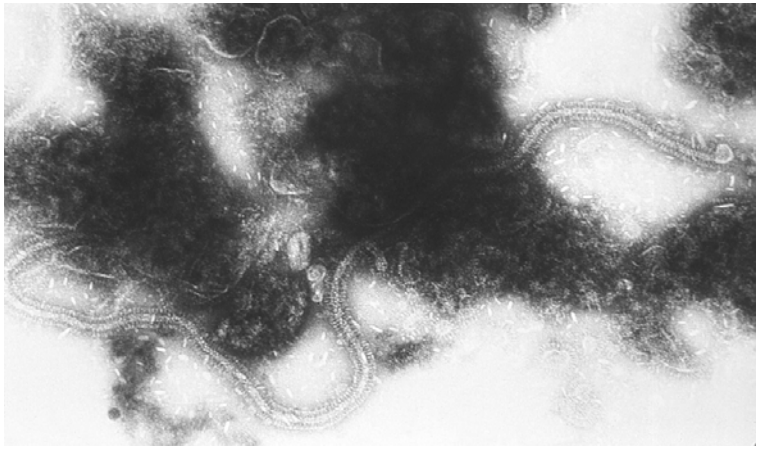
Winter temperature increases +0.40°F/ decade from 1950-2019 in USA[1]

It took 25 weeks for the cumulative number of hospitalizations per 100,000 people due to influenza in 2014-2015 season where as in 2017-18 flu season only 18 weeks required to reach that level[2]

Rising temperature can influence the multiplication and decrease in extrinsic incubation period (EIP) of pathogens[3]

1. NOAA National Centers for Environmental information, Climate at a Glance
2. the Centers for Disease Control and Prevention (CDC)
3. Harvell et al., 2002 Climate warming and disease risks for terrestrial and marine biota

Respiratory syncytial virus (RSV)

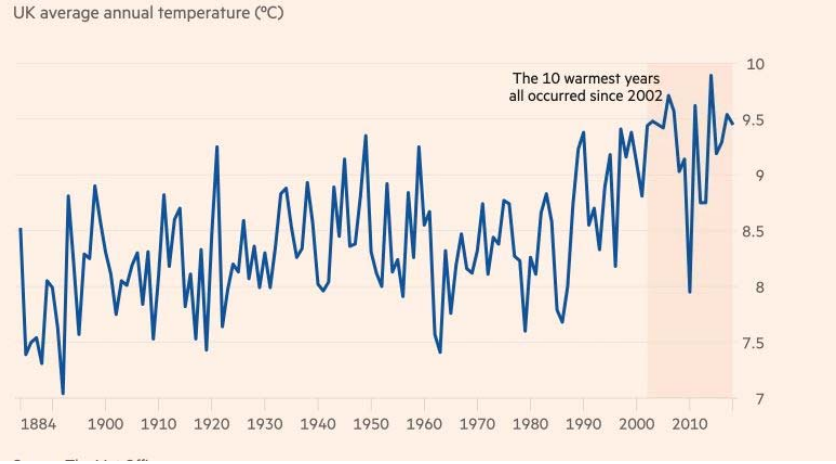


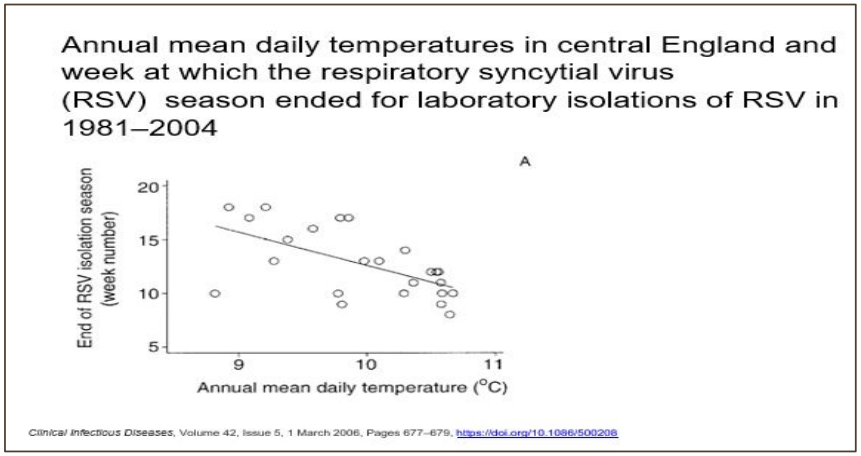
Transmission electron micrograph of RSV[1]

- A member of the species *Human orthopneumovirus*, a single stranded RNA virus
- Pathology
  - ❑infection of the airway, lungs and middle ear
- Transmission
  - ❑Direct contact with infectious secretions by droplets spread
  - ❑indirectly through contaminated hands, eating utensils or articles freshly soiled by nasal or throat discharges of an infected person
- Symptoms
  - ❑Congested or runny nose
  - ❑Dry cough
  - ❑Low-grade fever
  - ❑Sore throat
  - ❑Mild headache
- Diagnosis
  - ❑Nasal swabs
- Treatment
  - ❑ oxygen therapy

1. Centers for Disease Control and Prevention (CDC)
2. Centre for health protection, Hong Kong.

Warmer winters decrease RSV seasonality pattern





- UK experienced the 10 warmest years between 2000-2010 and their annual temperatures increase over last century
- In England, each 1°C increase in annual temperature between 1981 and 2004, the RSV season terminated between 2.5 and 3.1 weeks earlier[2]
- Rising temperature can influence the multiplication and decrease in extrinsic incubation period (EIP) of pathogens[3]

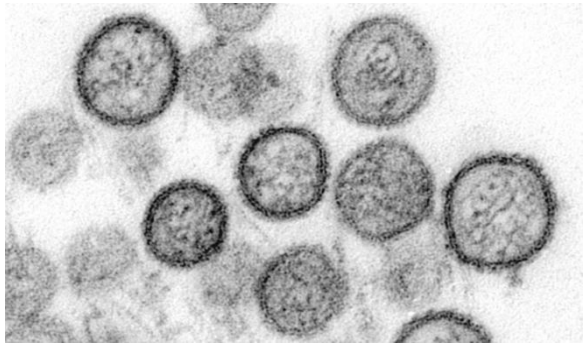
1. Haynes AK et al. (2014). Centers for Disease Control and Prevention (CDC). Respiratory syncytial virus: United States, July 2012-June 2014.
2. Donaldson GC. (2006) Climate change and the end of the respiratory syncytial virus season.
3. Zhang XL et al. (2013). Temporal characteristics of respiratory syncytial virus infection in children and its correlation with climatic factors at a public pediatric hospital in Suzhou.

Increase precipitation increases dissemination of pathogens

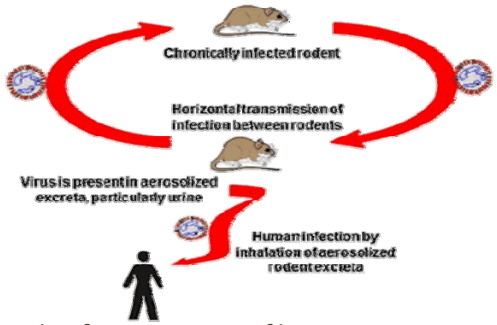
- Climate change cause shifts in precipitation
- Unusual precipitation after a long drought can result in an increase of pathogens
- Changes in precipitation may impact disease vectors/hosts
- Many vector-borne infectious diseases are found to be positively associated with rainfall
- However, rainfall is not always agreeable for vectors

1. M.B. Hoshen, A.P. Morse (2004) A weather-driven model of malaria transmission
2. K.L. Gage (2008). Climate and vectorborne diseases

Hantavirus



Transmission electron micrograph of hantavirus[1]



cycle of transmission of hantaviruses[2]

- Single-stranded, enveloped, negative-sense RNA virus in the family *Hantaviridae*
- Vector born disease
  - ❑Infect humans when contacted with rodent urine, saliva, or feces
- Pathology
  - ❑Hantavirus hemorrhagic fever with renal syndrome (HFRS)
  - ❑Hantavirus pulmonary syndrome
- Symptoms
  - ❑Fever
  - ❑Cough
  - ❑Abdominal pain
  - ❑Shortness of breath
  - ❑38% mortality
- Diagnosis
  - ❑Clinical examination
- Treatment
  - ❑No specific treatment, cure, or vaccine for hantavirus infection
  - ❑Patients are intubated and given oxygen therapy

1. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)
2. 2. The Public Health Agency of Canada

Climate and season affect vector populations

- Changes in temperature, precipitation, relative humidity, and air pollution influence viral activity and transmission and may contribute to the size and severity of the epidemics
- Case report

  Canada → In 2013 and 2014, a substantial increase in the hantavirus pulmonary syndrome cases[2]

- Winter → Increased growth rate in urban rats
  - decreased competitors
  - decreased decomposition of garbage
- Followed by 2 to 3-fold increase in rainfall responsible for more human contact with infected animals

Figure 2: Distribution and total number of hantavirus pulmonary syndrome cases (n=109) reported in Canada, 1989 to 2014

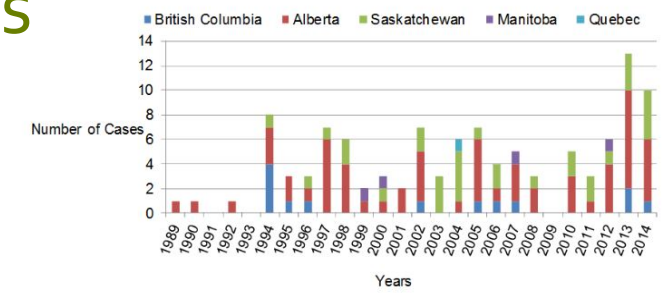
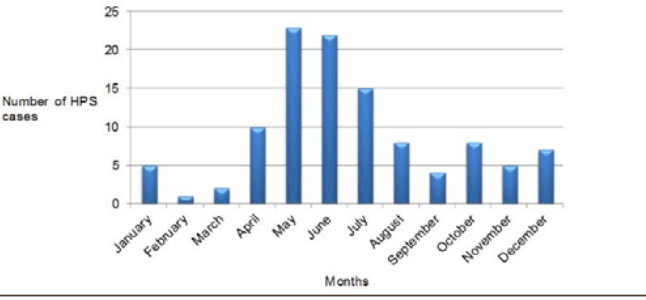
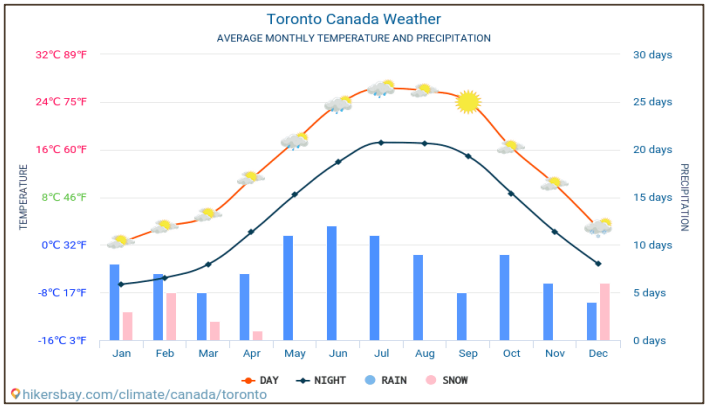


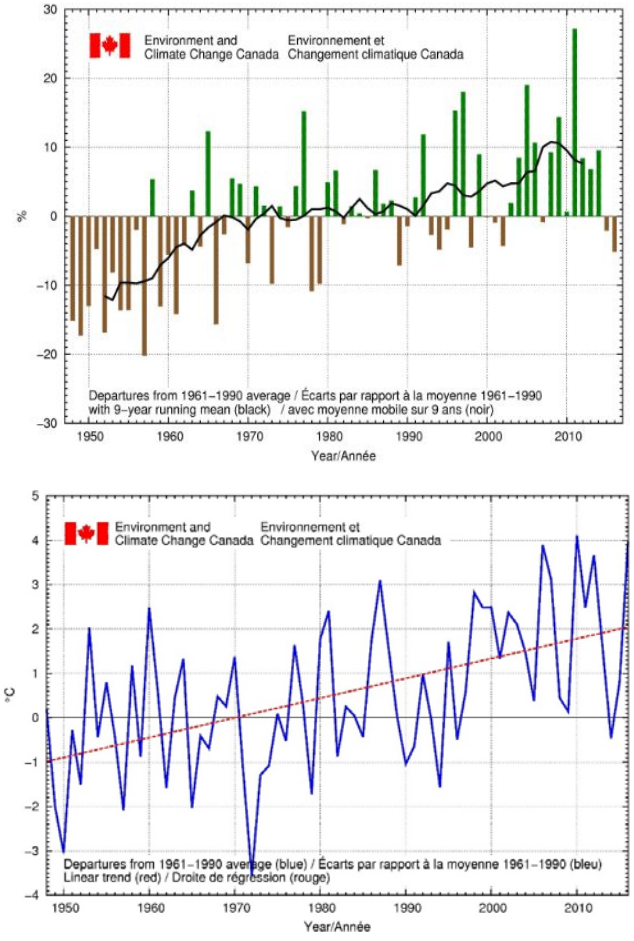
Figure 3: Seasonal distribution of hantavirus pulmonary syndrome (HPS) cases in Canada (n=109)





1. Bayard V et al. (2004). Outbreak of hantavirus pulmonary syndrome, Los Santos, Panama
2. The Public Health Agency of Canada

Winter national precipitation departures with nine-year running mean, 1948–2016



Increasing precipitation increase vector population

- Winter precipitation amounts have tended to be wetter in recent years
- Many vector-borne infectious diseases are found to be positively associated with rainfall
- Vector development accelerates with increased rain and rising temperature
- Droughts limit the quantity and quality of breeding sites for these vectors
- Increase in temperature and precipitation increases the vector population → increase human contact with infected animals

1. Bayard V et al. (2004). Outbreak of hantavirus pulmonary syndrome, Los Santos, Panama
2. The Public Health Agency of Canada

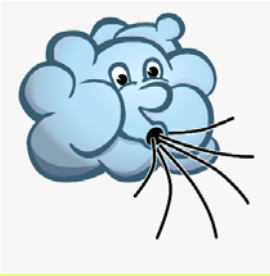
Humidity change impacts the pathogens

- The pathogens of air-borne infectious disease such as influenza tend to be responsive to humidity condition
- Absolute humidity and temperature were found to affect influenza virus transmission and survival
- Cold temperature and low relative humidity are favorable to the spread of influenza virus
- Many disease hosts tend to respond strongly to humidity change
- low humidity, especially when coupled with high temperature, forms unfavorable condition for some vectors, limiting the spread of the related infectious diseases
- Air-borne fungal diseases spread fast when humidity is low

1. K. Senior 92008) Climate change and infectious disease: a dangerous liaison?

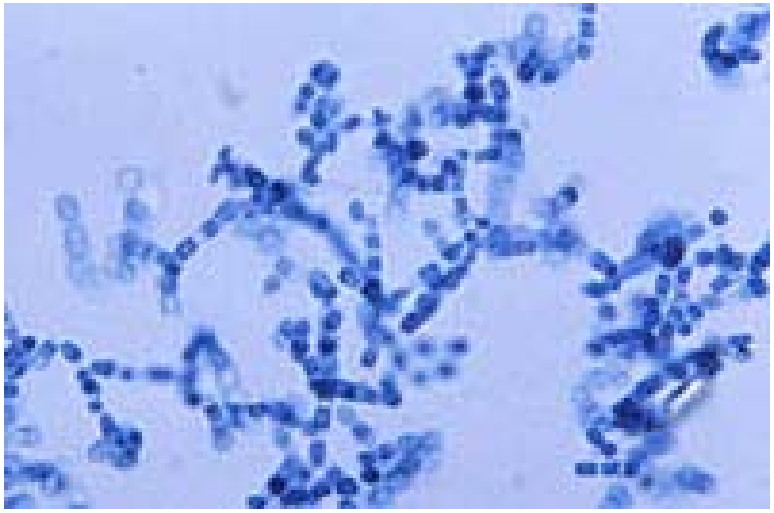
Wind helps dissemination of pathogens

- Wind is a key factor affecting the pathogens of air-borne diseases
- Positive correlation between dust particle association/attachment and virus survival/transporting
- Presence of desert dust in the atmosphere during Asian dust storms (ADS) is associated with increased concentration of cultivable bacteria, cultivable fungi, and fungal spores
- Concentration of influenza A virus was significantly higher during the ADS days than normal days
- Viruses of infectious diseases be transported across ocean by dust particles which may facilitate the transmission of viruses between distant hosts
- Pathogens can spread from endemic regions to other regions through interregional dust storms.
- Human influenza virus could be transported from Asia to the Americas in winter months by prevailing wind over the Pacific
- Avian influenza outbreaks tend to occur in downwind regions of ADS during the dust storm season



1. C. Reid (2000) Implications of Climate Change on Malaria in Karnataka, India
2. P.S. Chen (2010) Ambient influenza and avian influenza virus during dust storm days and background days

Coccidioides species



Photomicrograph showing arthroconidia of Coccidioides (environmental form)[1]

- fungus *Coccidioides*
- Pathology
  - ❑Valley fever
  - ❑ Disseminated coccidioidomycosis
- Transmission
  - ❑by breathing in the microscopic fungal spores from the air
- Symptoms
  - ❑Fatigue (tiredness)
  - ❑Cough
  - ❑Fever
  - ❑Shortness of breath
  - ❑Headache
  - ❑Night sweats
  - ❑Muscle aches or joint pain
  - ❑Rash on upper body or legs
- Diagnosis
  - ❑*Coccidioides* antibodies or antigens
- Treatment
  - ❑ 3 to 6 months of fluconazole

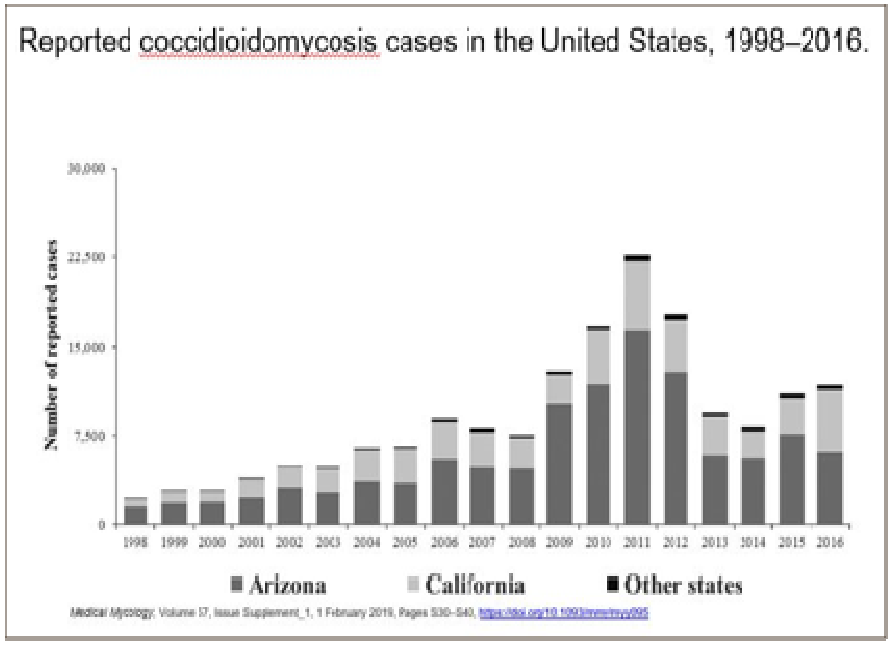
1. Centre for disease control and prevention (CDC)

Drought contributes *Coccidioides'* to expand

- Increased respiratory fungal infections have been reported after storms, earthquakes etc.
- Fungi growth and dispersal are sensitive to changes in temperature, moisture, and wind.

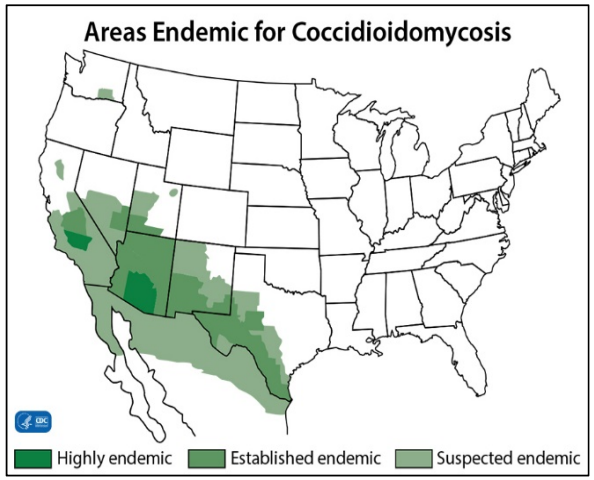
- Coccidioidomycosis outbreak occurred in California were well documented
  1. In 1977[1], 130 newly diagnosed cases after exposure to a severe natural dust storm
  2. In 1994[2], 203 new cases after an earthquake

- Peak exposure to this fungus occurs between June - November when the land is dry and dusty[3,4]

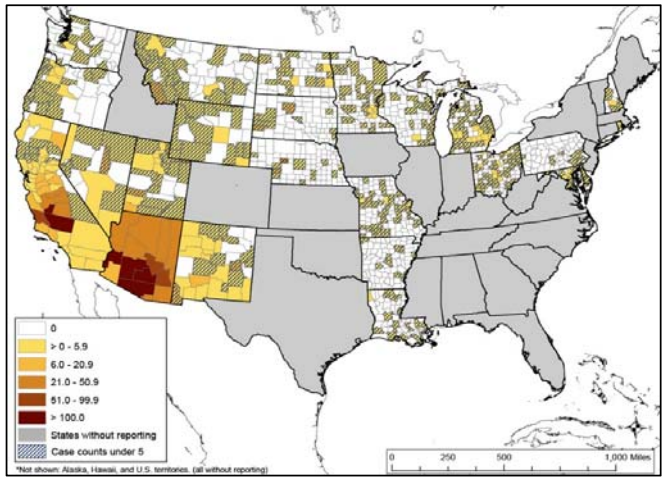


1. Williams PL et al. (1979) Symptomatic coccidioidomycosis following a severe natural dust storm: an outbreak at the Naval Air Station, Lemoore, Calif.
2. Schneider E et al. (1997).A coccidioidomycosis outbreak following the Northridge, Calif, earthquake.
3. Comrie AC. (2005) Climate factors influencing coccidioidomycosis seasonality and outbreaks
4. Park BJ et al. (2005). An epidemic of coccidioidomycosis in Arizona associated with climatic changes, 1998-2001. J Infect Dis 2005

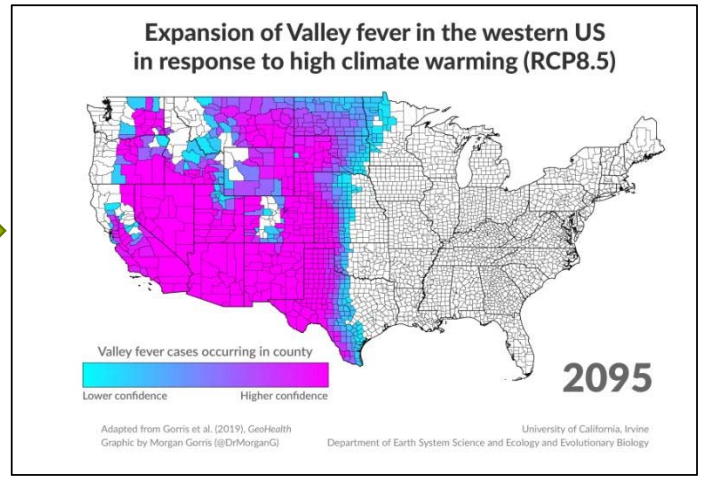
infectious diseases will move from one region to another



Late 1940s and early 1950s



During 2011–2017



In future….

1. Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases

The Case of Hong Kong

Hong Kong / Society

Hong Kong chokes as higher than normal pollution levels spark health warning for elderly and those with heart or respiratory illnesses

- Environmental Protection Department said it recorded higher than normal pollution levels since noon on Saturday
- Air pollution level expected to remain higher than normal until the advent of stronger winds

Kanis Leung
Published: 9:56pm, 19 Oct, 2019

world's highest average increase of urban ambient temperature during the past century[1]

Hong Kong Observatory predicts that annual mean temperature will rise by 3 to 6 ˚C in the 21st century[2]

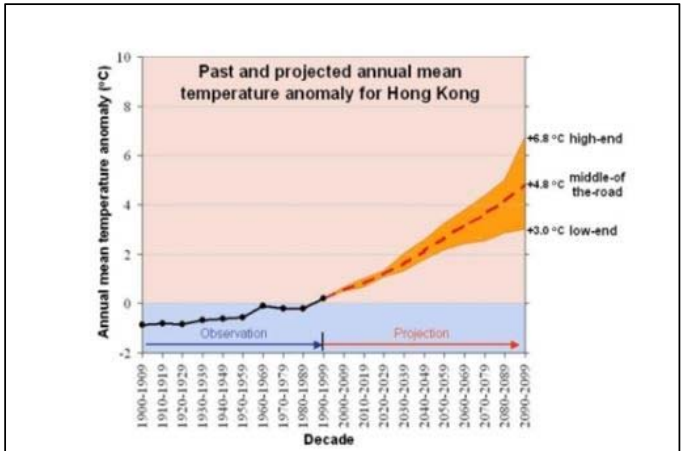
1˚C increase in daily mean temperature above 28.2˚C associated with an estimated 1.8% increase in mortality[3]

The monthly mean temperatures from June to September are all above 28.2 ˚C[2]

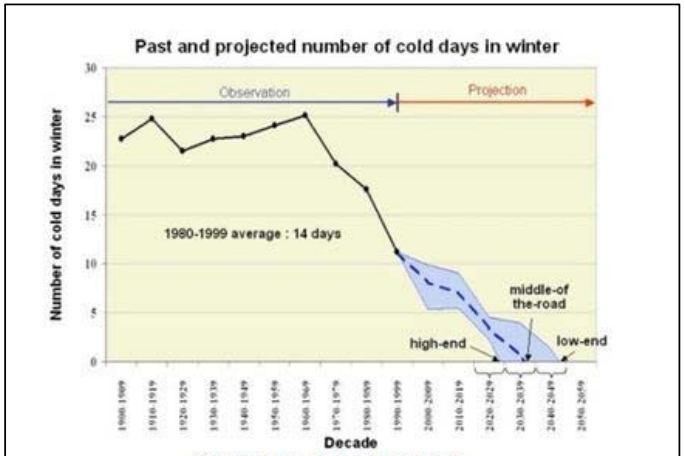
1. Centre for health protection, Hong Kong
2. Hong Kong Observatory
3. Hong Kong climate change report 2015

How will Hong Kong be Affected by Climate Change?

- Climate change in Hong Kong can be attributed to both global warming caused by increased atmospheric concentrations of greenhouse gases, and localised urbanization[1,2]
- Urban heat island is caused by a combination of factors including changes in surface as vegetation is replaced by concrete and tarmac[1,2]
- By the end of this century, annual mean temperatures will rise on average by 4.8 °C to an average of 27.8 °C1(compared to 23°C in 1990) [1,2]
- **By 2100,** there will be less than one cold day a year (12°C or below), meaning that for some winters, there will not be any cold days at all, and winter could disappear in Hong Kong[1,2]



Source: Hong Kong Observatory (2007): Temperature Projections for Hong Kong Based on IPCC Fourth Assessment Report



Source: Hong Kong Observatory

1. Hong Kong Observatory
2. Climate change business forum. The Hong Kong business guide to emission reduction

Conclusion

- Climate change carries a threat to human health and health care systems in the coming decades
- The occurrence of many infectious respiratory diseases is affected by climate and its corollary, air pollution
- The range of influences on viral infections, disease causing vectors, and host susceptibility with climate enhances these concerns
- Knowledge of these associations is important to adapt public health policies, disaster preparedness, societal awareness, and education
- Preparation for the deleterious human health effects of climate change must include measures to prevent or mitigate the occurrence and prevention of respiratory infections
- Much more needs to be learned and done in this area

unicef

Wait a Minute….!

Children are the least responsible for climate change

Yet they will bear the greatest burden of its impact

Without urgent action, a whole generation is at risk


Thank You!