Viruses Emerging in Australia: The ( Likely) Influence of Climate Change

Viruses in May, ’10
Katoomba

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Newly Emerging Diseases (Morens et al, 2004)

13 of 17 are viral
Re-Emerging Diseases (Morens et al, 2004)

7 of 21 are viral
Breaches in the species barrier: Selected emerging infections in humans since 1976

<table>
<thead>
<tr>
<th>Infection</th>
<th>Animal linked to transmission</th>
<th>Year infection first reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ebola virus</td>
<td>Bats</td>
<td>1976</td>
</tr>
<tr>
<td>HIV-1</td>
<td>Primates</td>
<td>1981</td>
</tr>
<tr>
<td>E. coli O157:H7</td>
<td>Cattle</td>
<td>1982</td>
</tr>
<tr>
<td>Borrelia burgdorferi</td>
<td>Rodents</td>
<td>1982</td>
</tr>
<tr>
<td>HIV-2</td>
<td>Primate</td>
<td>1986</td>
</tr>
<tr>
<td>Hendra virus</td>
<td>Bats</td>
<td>1994</td>
</tr>
<tr>
<td>BSE/vCJD</td>
<td>Cattle</td>
<td>1996</td>
</tr>
<tr>
<td>Austn lyssavirus</td>
<td>Bats</td>
<td>1996</td>
</tr>
<tr>
<td>H5N1 influenza A</td>
<td>Chickens</td>
<td>1997</td>
</tr>
<tr>
<td>Nipah virus</td>
<td>Bats</td>
<td>1999</td>
</tr>
<tr>
<td>SARS coronavirus</td>
<td>Palm civets</td>
<td>2003</td>
</tr>
<tr>
<td>Influenza (H1N1)</td>
<td>Swine</td>
<td>2009</td>
</tr>
</tbody>
</table>
Major factors enhancing infectious disease emergence and spread

Population growth, urban density: crowds, contacts
Peri-urban poverty: privation, under-nutrition, poor hygiene
Urbanization: sexual relations, mobility, mixing, etc.
Globalization: distance/speed of travel/trade
Intensified livestock production: BSE/vCJD, Nipah virus, bird ‘flu
Live animal food-markets: longer supply lines – SARS, HIV?, etc.
Disrupted ecosystems: dams, deforestation, biodiversity loss – e.g. various new Sth American rural haemorrhagic viral diseases
Global climate change
Biomedical exchange of human tissues: transfusion, transplants
Antibiotic use/misuse: humans, livestock production, house-plants
Increased human susceptibility: under-nutrition, population ageing, HIV, IV drug use, etc.
Temperature and tick-borne encephalitis (TBE) in Czech Republic

1993 to 2002: n=5,873 cases

\[ y = 0.6536x^{2.1743} \]
\[ R^2 = 0.9501 \]

Source: Daniel, et. al. 2006
Geographical distribution of Aedes albopictus* mosquito

Vector for:
- Dengue
- West Nile Virus
- Chikungunya
- Japanese encephalitis

Before 1980
Expansion 1981 to 2005
Nipah Virus Disease: Outbreak in Malaysian Pig Farmers, 1997-1999

Fruit bats (~40% carry the virus)

Rain Forest, with seasonal fruiting: bat food

Intensive pig farming

Virus-contaminated fruit, bat droppings

Eaten by pigs

Infected (sick) pigs

265 humans infected: JE-like illness
~40% fatal
~105 deaths
Projected Global Warming: IPCC (2007)

combined results of multiple model runs published by ~20 different modelling groups around world

Temperature projections, for 3 (of 6) different emissions projections:

- **A2**: relatively high emissions
- **A1B**: mid-level emissions
- **B1**: low emissions

Atmosphere concentrations remain as in 2000

Since 1950: + 0.7°C

Reference 1980-99 temperature

1.8 - 4.0°C

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2007
Earth’s Temperature Chart, since Dinosaur Extinction 65m yrs ago

* Global temperature measured at deep ocean

Sea level 25-40 metres higher than now (Tripati et al Science 2009)
Satellite-based measures of average global temperature (near-surface lower atmosphere), by year (Sept-Feb period), 1979-2010

Long-term uptrend continues

Temperature variation (°C), relative to reference temperature

Reference temperature, (1979-1998 average)

10 years of alleged ‘cooling’ since 1998 (popular ‘sceptic’ argument … i.e., before more recent data appeared)

Monthly data from: [http://data.giss.nasa.gov/gistemp/tabledata/GLB.Ts+dSST.txt](http://data.giss.nasa.gov/gistemp/tabledata/GLB.Ts+dSST.txt)
Best estimate (50th percentile) of change in average temperature (°C) over land by 2030 for A1B emission (‘medium’) scenario.
BoM: Best estimates of annual % change in precipitation (3 global emissions scenarios)

- **B1 (low)**
  - 2030
  - 2050
  - 2070

- **A1B**
  - 2030
  - 2050
  - 2070

- **A1FI (high)**
  - 2030
  - 2050
  - 2070

Legend:

-40% -20 -10 -5 -2 2 5 10 20 40%
Climatic conditions set the geographic and seasonal boundaries of potential transmission.

Other environmental, social and behavioural factors – and public health strategies – determine where/when actual transmission occurs.
Zoonoses: Climatic and Seasonal Variations in Vector and Host-Species

- **Vector-borne zoonoses mostly maintained by wildlife**
  - Humans are *incidental* to their ecology

- **Vectors and animal host species undergo seasonal and inter-annual variations in numbers and activities**
  - Vector activity reflects temperature and humidity
  - Host species population size and distribution affected by weather and (climate-related) resource availability

- **Pathogen may also be affected by climatic conditions**
Climatic Influences on Viral Disease Occurrence

Climate change

- Temperature
- Rainfall
  - Surface water
  - Humidity
  - Winds, drying, dust
  - Under-nutrition; social disruption & displacement

Viral replication rate

- Mosquitoes, ticks, etc.
- Animal reservoir

Natural habitat

- e.g. meningitis in W Africa

Vulnerability to ID

Human ID

Spill-overs

Human viral ID
Potential weeks of activity of *Aedes albopictus* mosquito in Europe (current): Spring hatching to Autumn diapause

Climate Change and Viral Diseases of Interest in Australia

Vector-borne

*Human only:* Dengue fever, Chikungunya (?)

*Zoonotic:* Ross River, Barmah Forest, MVE, Kunjin, Japanese encephalitis

Contagious, person-to-person

Influenza (emergence and spread of new strains)

*Respiratory syncytial virus*

?? Changes in contact probabilities and behaviours
- hep B, hep C, HPV, HIV
DENGUE FEVER: Estimated geographic region suitable* for *A. aegypti* vector, and hence transmission:
Climate conditions now and in alternative scenarios for 2050

Current risk region, for dengue transmission

2050 risk region: Medium GHG emissions scenario

2050 risk region: High GHG emissions scenario

* Global statistical model (Hales), applied to Australia: Function of water vapour pressure (rainfall humidity).

NCEPH/CSIRO/BoM/UnivOtago, 2003
Areas suitable for **dengue transmission** in 2100 under 4 climate change scenarios (grey = ≥50% likelihood of transmission)

Bambrick et al., 2009, *Global Hlth Action*

Map-projection of changes to rainfall across Australia to 2100 under ‘dry’ and ‘wet’ scenarios. Based on published literature, then modelled how these changes would affect disease distribution over space and time.
No. of people in regions at high risk (≥50%) of dengue transmission, under four climate change scenarios

1. Hot/dry
2. Hot/medium humidity
3. Hot/wet
4. Warm (strong mitigation)

Modelling done for Garnaut Review, 2008-09, by ANU/UWS team
Is climate change increasing the northern limit of *Culicoides* vectors of Bluetongue virus in Europe?

Northern range of virus: 2004
Northern limit, *C. imicola* group: 2004
Northern range of virus: < 1998
Northern limit, *C. imicola* group: < 1998

Source: Purse et al, 2005
*Nature Reviews Microbiology*
Surveillance data on distribution of bluetongue and culicoides vector from National Arbovirus Monitoring Program, administered by Animal Health Australia.
“Currently, 40 years of intensive climate model development is being coupled to what amounts to a cottage industry of impact sciences.

“The result is that our understanding of how ecosystems, water, human health, agriculture, and energy will respond to climate change advances only slowly.”