Climate sensitive vector-borne diseases and outbreak response capabilities in the Pacific

Maxine Whittaker
Dean College Public Health, Medical and Veterinary Sciences
James Cook University
Townsville
Order of presentation

- Introduction to VBDs
- The impact of climatic changes on VBDs
- VBDs of major interest in the Pacific
- Capacities required to prevent/identify/respond to VBDs
- Assessment of these capacities in the Pacific
- Actions underway and needed

Source: https://wwwnc.cdc.gov/eid/article/20/6/13-1413-f1
Human impact

• Apprx. 40% percent of emerging zoonotic viruses are vector borne
• 1/6th human illnesses and disability suffered worldwide due to VBD
• > ½ world human population at risk of VBD
• Every year there are more than 1 billion cases and over 1 million deaths from vector-borne diseases, globally.
• Vector-borne diseases account for over 17% of all infectious diseases.
• Wide socioeconomic impacts – individual and societal
• Burden greatest for poor

# VBD AND MAJOR VECTOR DISTRIBUTION IN THE PACIFIC

<table>
<thead>
<tr>
<th>Disease</th>
<th>Country/Region</th>
<th>PICT/PNG Vectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dengue</td>
<td>Pacific wide</td>
<td><em>Aedes aegypti, Ae. albopictus, Ae. polynesiensis</em> and numerous others in scutellaris group</td>
</tr>
<tr>
<td>Chikungunya</td>
<td>FSM, New Caledonia, PNG, Tonga</td>
<td><em>Ae. aegypti, Ae. Albopictus, Ae. polynesiensis</em></td>
</tr>
<tr>
<td>Zika virus</td>
<td>Cook Islands, FSM, French Polynesia, New Caledonia, PNG</td>
<td><em>Ae. hensilli, Ae. aegypti</em></td>
</tr>
<tr>
<td>Lymphatic filiariasis</td>
<td>Pacific wide (except 6 countries)</td>
<td><em>Culex quinquefasciatus, Anopheles farauti, Ae. albopictus,</em></td>
</tr>
<tr>
<td>Malaria</td>
<td>PNG, Solomon Islands, Vanuatu.</td>
<td><em>An. farauti, An. hinesorum, An. punctulatus</em></td>
</tr>
<tr>
<td>Epidemic polyarthritis (Ross River Virus)</td>
<td>Cook Islands, Fiji, New Caledonia, PNG, Samoa, Tonga</td>
<td><em>Ae. vigilax, Cx. annulirostris, Ae. polynesiensis</em></td>
</tr>
<tr>
<td>Japanese encephalitis</td>
<td>Micronesia, North Mariana, PNG</td>
<td><em>Cx. tritaeniorhynchus, Cx. annulirostris, Cx. sitiens</em></td>
</tr>
</tbody>
</table>
Not as widespread but still climate sensitive (maybe under measured)

<table>
<thead>
<tr>
<th>Disease/Disease group</th>
<th>Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Nile fever</td>
<td><em>Culex</em></td>
</tr>
<tr>
<td>Relapsing fever (borreliosis) (Guam disease)</td>
<td>Ticks</td>
</tr>
<tr>
<td>Rickettsial disease (Babesia)</td>
<td></td>
</tr>
<tr>
<td>Tick borne encephalitis</td>
<td></td>
</tr>
<tr>
<td>Rickettsiosis</td>
<td>Fleas</td>
</tr>
<tr>
<td>Scrub typhus (Temotu fever)</td>
<td>Mites (incl. Trombiculid)</td>
</tr>
</tbody>
</table>
Concurrent outbreaks of dengue, chikungunya and Zika virus infections – an unprecedented epidemic wave of mosquito-borne viruses in the Pacific 2012–2014

Since January 2012, the Pacific Region has experienced 28 new documented outbreaks and circulation of dengue, chikungunya and Zika virus. These mosquito-borne disease epidemics seem to become more frequent and diverse, and it is likely that this is only the early stages of a wave that will continue for several years. Improved surveillance and response measures are needed to mitigate the already heavy burden on island health systems and limit further spread to other parts of the world.
**Figure 1:** Schematic summary of main pathways by which climate change affects population health

Mitigation refers to true primary prevention (reducing greenhouse gas emissions). Adaptation (a form of late primary prevention) entails interventions to lessen adverse health effects.

Changes in vector-pathogen-host relations and in infectious disease geography/seasonality—e.g., malaria, dengue, tickborne viral disease, schistosomiasis

McMichael A et al 2006
Table 29-1 | Climate change projections for the intermediate low (500–700 ppm CO$_2$e) Representative Concentration Pathway 4.5 (RCP4.5) scenario for the main small island regions. The table shows the 25th, 50th (median), and 75th percentiles for surface temperature and precipitation based on averages from 42 Coupled Model Intercomparison Project Phase 5 (CMIP5) global models (adapted from WGI AR5 Table 14.1). Mean net regional sea level change is evaluated from 21 CMIP5 models and includes regional non-scenario components (adapted from WGI AR5 Figure 13-20).

<table>
<thead>
<tr>
<th>Small island region</th>
<th>RCP4.5 annual projected change for 2081–2100 compared to 1986–2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>Caribbean</td>
<td>1.2</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>2.0</td>
</tr>
<tr>
<td>Northern tropical Pacific</td>
<td>1.2</td>
</tr>
<tr>
<td>Southern Pacific</td>
<td>1.1</td>
</tr>
<tr>
<td>North Indian Ocean</td>
<td>1.3</td>
</tr>
<tr>
<td>West Indian Ocean</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Vector-borne infections: Mosquito-borne infections tend to increase with warming and certain changes in rainfall patterns: heightened transmission. Likewise tick-borne infections, although via more complex ecological changes

Mosquito reproduction and survival could be impaired by altered rainfall and surface water and by excessive heat: reduced transmission. Similar determinants may apply to ticks, snails and other vectors.

McMichael A et al 2006
ENSO

ECOTOPE
- Temperature (minimum, maximum, diurnal variation)
- Precipitation
- Relative humidity
- Wind
- Vegetation cover
- Water cover
- Animal (primary, intermediate hosts, Reservoirs, Predators)

HOST

PARASITE OR PATHOGEN
- Sufficient

VECTOR
- Competent

ANIMAL ENVIRONMENT
- Density
- Diversity
- Herd Structure
- Movement

Vectors
- (competence, life stages, density, feeding, breeding, fitness, longevity)
- Symbiotic microbes

HUMAN ENVIRONMENT
- Human biology (age, genotype, gender, immunity, pathogen burden, blood types, ? microbiome)
- Human behaviour
- Socioeconomic
- Demographics
- Living conditions (housing, water supply, sanitation, waste)
- Urbanisation
- Migration
- Mobility
- Health services
- Public policies (like public health, environmental, land use, economic)

Adapted from: Wu et al 2016, Rodhain, 1985; Parham et al 2015; Campbell-Lendrum et al 2015
A pathogen/parasite

• Needs a certain temperature range to survive and develop
• Rising temperatures can affect reproduction and extrinsic incubation period and other aspects of parasite development rates
• Extended period of hot weather can raise the temperature of environments of -> change density of pathogens
• Rising temp. may limit proliferation of a pathogen by favouring competitor
• Combinations of factors often important
Challenges:

- Many health challenges
- Low economic bases
- Large territorial areas and limited communication and logistics constraints
- Scale
- Population mobility and birth rates
  - Sufficient susceptible hosts for DENV epidemic every 4-5 yrs (Cao-Lormeau et al. 2014)

Health systems capacity
- PICTS struggle to comply with Core Capacity building for IHR, too complex, many partners irrelevant (Gardner 2014)
- Workforce numbers and levels (Craig et al. 2015)*
- Data quality and timeliness (Saketa 2015)
- Laboratory surveillance
- One health capacity

Strengths and opportunities

• Resilient communities and social structures
• Partners/Support
  • SPC
  • WPRO
  • Australian and New Zealand government
  • CDC
  • Pasteur institute
  • China
  • Pacific Public health Surveillance network (PPHSN), PacNET, LabNet, EpiNet, PICNet
• Fiji National University with SPC Data for decision making accredited training programme for Pacific
• PNG Field Epidemiology training program (with CDC and WHO)
• Pacific data for decision making
• Asia Pacific Strategy for Emerging Diseases (APSED)
• Asia Pacific Strategy for Strengthening of Health Laboratories
• APMEN
• Pacific Outbreak Manual
• PacELF
Core public health capacities for effective response to VBD – emerging, re-emerging or evolving

Source: WHO 2005
IHR 2015

• Strong national public health systems that are able to maintain active surveillance of diseases and public health events;
• Rapidly investigate detected events;
• Report and assess public health risks;
• Share information;
• Implement public health control measures

• 14 are State parties to IHR
• 6 assessed (2015) as gaps in core critical areas
Experience in vector control

• “The expertise of entomologist is critical to guiding vector control; however the world is facing an extreme shortage of entomologists” WHO 2014 pg 45

• Vector control capacity in pacific limited or insufficient No ongoing entomological surveillance system targeting vectors of dengue or other arboviruses except New Caledonia, Fiji and French Polynesia: Roth et al 2014

• Most data on mosquito distribution on data collected 2nd half 20th century

• Little done to build local infrastructure and skills needed to improve efficiency, monitor impact, sustain coverage with vector control interventions, and insecticide resistance monitoring
So what can we do?

• Support capacity building efforts commenced by Pacific island countries and territories and partner agencies
  • Advocacy for resourcing
  • Mentoring
  • Developing training opportunities in partnership
  • Apply research efforts to problems pacific partners identify and face – and implement as true partnerships
  • Tools development to support efforts
  • Innovative continuing professional development opportunities
  • Personal actions re: climate change

-> Flexible adaptive resilient health systems and Pacific neighbours partnerships to cope with changes the direction of which may be unpredictable
International Day of the Tropics

#WeAreTheTropics

29th June
## Climate-related drivers of impacts

<table>
<thead>
<tr>
<th>Driver</th>
<th>Level of risk &amp; potential for adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warming trend</td>
<td>Potential for additional adaptation to reduce risk</td>
</tr>
<tr>
<td>Extreme temperature</td>
<td>Risk level with high adaptation</td>
</tr>
<tr>
<td>Drying trend</td>
<td>Risk level with current adaptation</td>
</tr>
<tr>
<td>Extreme precipitation</td>
<td></td>
</tr>
<tr>
<td>Damaging cyclone</td>
<td></td>
</tr>
<tr>
<td>Sea level</td>
<td></td>
</tr>
<tr>
<td>Ocean acidification</td>
<td></td>
</tr>
<tr>
<td>Sea surface temperature</td>
<td></td>
</tr>
</tbody>
</table>

### References
• Craig, A et al 2016 Early warning surveillance in the Pacific Island nations: an evaluation of the Pacific syndromic surveillance system Tropical medicine and international health 21: 917-927

• Craig, A., Ronsee, A., Hardie, K., Pavlin, B., Biaukula, V., Nilles, E 2015 Risk posed by the Ebola epidemic to the pacific islands: findings of a recent WHO assessment WPSAR 6(2) 45-50 www.wpro.who.int/wpsar


• Hanna, E., Harley, D, Xu, C., McMichael, A 2011 Overview of climate change impact on human health in the Pacific Region Report to Commonwealth of Australia Dept. Climate change and energy efficiency Canberra: ANU

• IPCC 2014 Chapter 29 — Small Islands - IPCC


• Marks, M., Joshua,, C., Longbottom, J., et al 2016 An outbreak investigation of scrub typhus in Western province, Solomon Islands 2014 WPSAR 7(1) 6-9

• Merianos A 2016 A Defining health security for the Pacific: Global and WPRO action frameworks and alignment to USAPI priorities PIHOA 60th Executive Board Meeting Honolulu 30 Aug - 1 Sept 2016


• Roth, A., Mercier, A., Lepers, C et al 2014 Concurrent outbreaks of dengue, chikungunya and Zika virus infections- an unprecedented epidemic wave of mosquito-borne viruses in the Pacific 2012-2014 Euro Surveill 19(41):pii=20929


• Vander Velde N., Vander Velde B 2013 Known and potential ticks and tick borne pathogens of Micronesia Micronesica 2013-01, 1-26

• WHO 2014 A global brief on vector borne diseases Geneva: WHO


• WHO 2005 Asia Pacific Strategy for emerging diseases New Delhi/Manila WHO