An interdisciplinary study of typhoid fever in Central Division, Republic of Fiji

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Outline

• The study framework
• Where are the cases – GIS
• Case /control
• Environmental investigations
• Molecular detection - rPCR
Salmonella Typhi bloodstream infections detected by passive surveillance, Fiji, 1991 - 2014

Adapted from Kool et al. 2010
Primary threats to natural systems
Conceptual model of mechanisms determining health in high island river basins

Cyclones & Heavy Rain → Runoff → Damage to Infrastructure, Animal & Human Density, Sediments & Nutrients

Runoff → Contaminated food & water → Bacterial Carriage (e.g., S. Typhi)

Damage to Infrastructure → Human Well-Being (Disease Burden, Nutrition & Livelihoods)

Animal & Human Density → Sociocultural/Behaviour

Sediments & Nutrients → Food Fish & Invertebrates

River & Reef Health

Interdisciplinary research elements

Case control study (2014-15):

- Geospatial analysis (2008-2014)

- Environmental-Microbiological (water, soil)

- Molecular detection (rPCR & sequencing)

- Outcome harvesting

- Catchment Health Index (Typhoid epidemiology, flood risk, resource availability)

Typhoid resurgence

Is it related to aquatic resource decline?
Rural high incidence setting
Urban high incidence setting
Geospatial distribution of cases (2013-2014)
Potential landscape/temporal predictors:

- Forest cover
- Road density
- # River crossings
- Level of cultivation
- Relative Erosion Potential
- Rainfall
Environmental sampling

- Water – stored, source, nearby stream
- Soil – toilet, toilet drain, household garden
- On site – Temp, pH, conductivity, DO
- Lab process – Total Coliforms, *E. coli*
- Filtered (0.4 microns) – stored for PCR
- Filtrate – Nitrates, Phosphates, Ammonia
Mean Most Probable Number of *Escherichia coli* in water & soil of cases & controls

**WATER**

- Stored
  - Cases: 16
  - Controls: 30
- Source
  - Cases: 22
  - Controls: 44
- Near Stream
  - Cases: 14
  - Controls: 21

**SOIL**

- Toilet
  - Cases: 12
  - Controls: 15
- Toilet Drain
  - Cases: 23
  - Controls: 45
- House Garden
  - Cases: 21
  - Controls: 45

*Safe drinking/eating*

*Safe swimming*
Total Coliforms and *Escherichia coli* in Rural vs Urban Drinking Water

<table>
<thead>
<tr>
<th>Source</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Coliforms</td>
<td>26</td>
<td>46</td>
</tr>
<tr>
<td>E.coli</td>
<td>44</td>
<td>61</td>
</tr>
</tbody>
</table>

Mean Most Probable Number CFUs / 100ml +/- se

* indicates statistically significant difference.
Mean concentration of nutrients in water & soil of cases & controls

**WATER**

**SOIL**

**Mean concentration (mg/L) +/- se**

- **Phosphate**
  - Case: 3.0 ± 0.5
  - Control: 1.5 ± 0.5

- **Nitrate**
  - Case: 0.2 ± 0.1
  - Control: 0.1 ± 0.1

- **Ammonia**
  - Case: 2.0 ± 0.5
  - Control: 1.0 ± 0.5

*Significant difference between cases and controls.*
Molecular detection

• rPCR on water & soil samples

• Assay works in soil... a first?

• 5 positives from 50 samples – all case houses
Muddy water below house entrance
Conclusions

• In endemic, high-incidence, flood prone settings environmental sources of exposure are likely
• Localized behaviors, household environments or river basin settings may enhance risk of typhoid
• Focus on natural and built infrastructure + vaccination
• Pacific Islands as model systems for typhoid control and elimination?
Said Lao Tsu, 2,500 years ago.

“Thirty spokes share the wheel’s hub;
It is the center hole that makes it useful.”
THANK YOU

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