RISK FACTORS ASSOCIATED WITH ENVIRONMENTALLY-TRANSMITTED ZOONOSES HOSPITALISATIONS IN QUEENSLAND

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I acknowledge the traditional custodians of the land where this research was done, and pay respects to their elders past, present and emerging.

I recognize that this has always been a place of teaching and learning.
Zoonoses

• Infectious diseases transmitted between vertebrate animals and humans

• 60% of human infectious diseases are zoonotic in nature (Andersen et al. 2020).

Zoonotic influenza.
Salmonellosis.
West Nile virus.
Plague.
Emerging coronaviruses
Rabies.
Brucellosis.
Lyme disease.
Zoonoses

- Bacteria, viruses, protozoa and fungi

- Many transmission pathways mediated by environment conditions (waterborne, airborne, soil-transmitted and vector-borne)

- Public health impacts (BoD)
• Largest number of locally-acquired cases of Salmonellosis and Campylobacteriosis (most common foodborne diseases due to zoonotic pathogens in Australia) (OzFoodNet, 2018).

• high incidence of vector-borne diseases (Ross River Virus, Barmah Forest disease and zoonotic faecal-oral parasitic such as toxocarasis, strongyloidiasis and hookworm infections) (Chakma et al. 2017; Choy et al. 2000; Lau et al. 2010; Zahedi et al. 2018).

• Highest Q fever incidence in AU (twice + the national rate) (Queensland Health 2019).

• Transmission pathways involve contaminated environments (e.g. air, soil, water) | also for other zoonoses such as Cryptosporidiosis, Leptospirosis, Melioidosis
Zoonoses – Queensland – notifications

Campylobacteriosis

Zahedi et al, (2019)

Moffat et al, (2017)

Cryptosporidium

Chakma et al, (2017)

Zahedi et al, (2019)
Zoonoses – Queensland – spatial

Hu et al, (2010)
What environmental and sociodemographic factors are determinant of hospitalisations due to environmentally-transmitted zoonoses in Queensland?
Methods

Regression model *

\[ y_i \sim \text{Poisson}(\lambda_i) \quad \text{for}\quad i^{th}\text{ Local Goverment Area (LGA)} \]

\[ \rho_i = \frac{\log(\lambda_i)}{\log(\text{pop}_i)} = \text{standardised rate of zoonoses hospitalisation (zHR)} \]

\[ \eta_i = \log(\rho_i) = \alpha + \beta_x X_{xi} + s_i + u_i \]

\( \beta_x X_{xi} \) = list of risk factors and coefficients:

- Index Social Disadvantage (ISD)
- zHR – females
- sR – at risk occupations
- Temperature
- Rainfall

\( s_i = \text{spatial structured component – spatial distribution of the LGAs} \)

\( u_i = \text{unstructured component (random effects)} \)

A mixed effects regression model - Bayesian approach using the R-INLA package \(^1\)

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Sensitivity analysis of the spatial matrix:
Queen Vs
KNN 5, 7, 9, 11

(DIC to identify the best fit)
Deviance Information Criterion of the models compared

<table>
<thead>
<tr>
<th>Model</th>
<th>Prior 1</th>
<th>Prior 2</th>
<th>Prior 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayesian spatial model using a queen AM</td>
<td>831.419</td>
<td>812.9744</td>
<td>818.0272</td>
</tr>
<tr>
<td>Bayesian spatial model using a KNN=5 AM</td>
<td>1286.908</td>
<td>1286.798</td>
<td>1287.077</td>
</tr>
<tr>
<td>Bayesian spatial model using a KNN=7 AM</td>
<td>1286.971</td>
<td>1286.814</td>
<td>1287.075</td>
</tr>
<tr>
<td>Bayesian spatial model using a KNN=9 AM</td>
<td>1286.966</td>
<td>1286.823</td>
<td>1286.714</td>
</tr>
<tr>
<td>Bayesian spatial model using a KNN=11 AM</td>
<td>1286.923</td>
<td>1286.956</td>
<td>1286.730</td>
</tr>
</tbody>
</table>

Notes. AM: Adjacency matrix
## Results

Summary statistics of zoonoses hospitalisations and socio-environmental factors by LGA in Queensland

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Q1</th>
<th>Median</th>
<th>Q3</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardised hospitalisation rate of zoonoses (zHR)</td>
<td>0.004</td>
<td>0.008</td>
<td>0.000</td>
<td>0.001</td>
<td>0.002</td>
<td>0.005</td>
<td>0.064</td>
</tr>
<tr>
<td>Index of Socioeconomic Disadvantage (ISD)</td>
<td>957.7</td>
<td>69.6</td>
<td>472.1</td>
<td>946.3</td>
<td>972.5</td>
<td>992.4</td>
<td>1,048.9</td>
</tr>
<tr>
<td>Standardised female zoonoses hospitalisation rate</td>
<td>0.005</td>
<td>0.008</td>
<td>0.000</td>
<td>0.002</td>
<td>0.003</td>
<td>0.005</td>
<td>0.076</td>
</tr>
<tr>
<td>Standardised rate of people in at-risk occupations</td>
<td>0.139</td>
<td>0.116</td>
<td>0.000</td>
<td>0.035</td>
<td>0.104</td>
<td>0.211</td>
<td>0.412</td>
</tr>
<tr>
<td>Average maximum temperature*</td>
<td>2.809</td>
<td>0.253</td>
<td>2.136</td>
<td>2.640</td>
<td>2.790</td>
<td>2.947</td>
<td>3.342</td>
</tr>
<tr>
<td>Average rainfall**</td>
<td>8.037</td>
<td>4.527</td>
<td>2.269</td>
<td>5.264</td>
<td>6.502</td>
<td>8.861</td>
<td>29.159</td>
</tr>
</tbody>
</table>

Notes. Q1: first quartile value; Q3: third quartile value; SD: standard deviation; * °C x10⁻¹; ** mm x10⁻¹
Results

Distribution of zoonoses hospitalisations and socio-environmental factors in the Queensland LGAs.
Results

Exponentiated posterior mean - spatial regression model

<table>
<thead>
<tr>
<th></th>
<th>Posterior mean (CI)</th>
<th>SD</th>
<th>DIC</th>
<th>Spatial variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.001 (0.001-0.07)</td>
<td>10.637</td>
<td>812.97</td>
<td>0.86</td>
</tr>
<tr>
<td>Index of Socioeconomic Disadvantage</td>
<td>1.001 (0.998-1.004)</td>
<td>1.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardised female zoonoses hospitalisation rate</td>
<td>1.255 (1.154-1.365)</td>
<td>1.044</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardised rate of people in at-risk occupations</td>
<td>1.10 (1.051-1.151)</td>
<td>1.024</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average maximum temperature</td>
<td>0.701 (0.24-2.042)</td>
<td>1.723</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average rainfall</td>
<td>1.025 (0.973-1.078)</td>
<td>1.026</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. CI: 95% Credible Interval; SD: Standard Deviation; DIC: Deviation Information Criterion
Increase risk of 4-fold or more in 9 LGAs:

**North and northeast**
- Cardwell
- Johnstone
- Torres
- Herberton
- Eacham

**South**
- Paroo
- Murweh
- Roma

**Central**
- Barcaldine
Conclusions

• People working in animal-associated occupations have about 10% higher risk of environmentally-transmitted zoonosis hospitalisation in Queensland.

• These occupations link to commercial activities related to environmental interventions which can disrupt the ecological balance of habitats and pose a risk of exposure to zoonotic pathogens that survive for long periods in soil, water and air.

• Gender differences can play an important role in the severity of zoonotic infections. This could be associated with the presence of perinatal comorbidities and diminished immune response has found in previous research (Shaapan, R.M, 2016).
Conclusions

• Quantified geographical variation of hospitalisation risk and probability of excess of risk for specific LGAs in QLD

• Risk indicators per LGA can be used to set to support surveillance programs and design health rankings linked to public health strategies (Courtemanche C.S. et al, 2015)

• Limitations: Data limitation addressed with an ecological approach. Risk of ecological bias

• Further research is needed to identify potential biological mechanisms.
Thanks

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