Geo-Information and Zero-Inflated Poisson Regression Analysis for showing risk areas of Schistosomiasis mansoni in Rwanda

Elias Nyandwi, Tom Veldkamp, Frank Badu Osei, Sherif Amer

AfricaGIS 2017-Geospatial and Statistical information imperatives for the “Africa we want” UNECA Addis Ababa, Ethiopia, from the 20th to the 24th of November 2017

Country prevalence: 2.7%, District: 0-70% (school children)
Objectives

▪ To model the dynamic spatial pattern of schistosomiasis risk in Rwanda using a geostatistical model accounting for false zero cases,
▪ To develop a scenario for identification of potential future risk areas: should the current trends of the risk factors continue up to 2050, what would be the future spatial distribution of the risk of schistosomiasis?
NOVELTY: USE OF ROUTINELY COLLECTED CASE DATA

High Spatial and High Temporal Resolution

Laboratory confirmed Schistosomiasis cases collected monthly at health facility level, 2001 – 2012

Health Facility Service Areas accurately delineated and fused with population data from 2002 and 2012 Census
prevalence - incidence data: high correlation

Prevalence at surveyed schools compared to incidence in corresponding HFSA

\[ y = 0.0147x + 0.0335 \]
\[ R^2 = 0.7897 \]
SPATIO-TEMPORAL DYNAMICS OF SCHISTOSOMIASIS TRANSMISSION 2001 – 2012 (SATSCAN)
Modelling schistosomiasis risk areas

- Generate Zero Inflated Poisson (ZIP) regression model for 2001-2009 based on covariates identified by Nyandwi et al. 2017
- Use ZIP model to forecast schistosomiasis risk in 2050 accounting for
  - expected rainfall and temperature changes and their combined effect on spatial distribution of wetlands
  - planned expansion of intensified agricultural use of wetlands (i.e. rice cultivation)

Why ZIP: count data, over-dispersion, large number of zero counts at HFSA level
Schistosomiasis transmission – covariates

Covariates extracted for each Health Facility Service Area (HFSA)
ZIP Model: categorical and continuous covariates

| Parameters | Model 1 | | | Model 2 | | |
|------------|---------|--------|--------|---------|--------|
|            | Mean    | $Q_{0.025}$ | $Q_{0.975}$ | Mean    | $Q_{0.025}$ | $Q_{0.975}$ |
| $\beta_0$  | 0.000134 | 0.000069 | 0.000263 | 0.0000785 | 0.00003 | 0.00019 |
| $\gamma_1$ | 1.397   | 0.882   | 2.2071  | 1.688   | 0.989   | 2.891 |
| $\gamma_2$ | 1.289   | 0.765   | 2.166   | 1.292   | 0.669   | 2.485 |
| $\gamma_3$ | 1.322   | 0.828   | 2.098   | 1.498   | 0.837   | 2.893 |
| DIC        | 4970.10 |        |        | 4547.91 |        |        |
| $p_D$      | 296.45  |        |        | 336.84  |        |        |
Observed versus modelled RR 2001 - 2009

\[ y = 0.9805x + 0.0149 \]

\[ R^2 = 0.9 \]
Schistosomiasis transmission – covariates 2050

Covariates extracted for each Health Facility Service Area (HFSA)

- Proximity Wetland
- Presence Rice paddy
- Proximity Rice paddy
- Wetland proportion
- Temperature
- +4 mm per decade
- +0.35 C per decade

12,000 to 55,000 ha.
Future relative risk of schistosomiasis 2050

Persisting and emerging areas with elevated risk of schistosomiasis transmission:
- HFSA’s with or with close proximity to rice cultivation
- HFSA’s close to waterbodies
Summary and conclusion

Routinely collected case data can be used as complement to prevalence survey data (high spatial and temporal resolution, low-cost, potentially generalizable to other diseases)

Analysis at HFSA level is a suitable spatial scale for modelling, monitoring and mapping of schistosomiasis transmission across space and over time
Acknowledgements

➢ Dutch Government, Nuffic Programme under the NICHE/RWA/071 Project for Financial support
➢ Rwanda Biomedical Centre (RBC) and staff members for providing routine health data for 2001-2012
➢ Rwanda Natural Resources Authority (RNRA),
➢ Centre for GIS and RS of University of Rwanda (CGIS-UR)
THANKS FOR YOUR ATTENTION

In case of further interest: e.nyandwi@ur.ac.rw