Using modelling tools for understanding and addressing the impacts of climate change on infectious diseases in Malawi

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Background

- Climate variation/change has potential to derail malaria control/elimination efforts.
- Alter patterns of other infectious diseases such as cholera.
- Increased frequency of extreme events – cyclones, droughts.
- Weak health systems also vulnerable to climate shocks.

Background

- Models show an increase in malaria over the coming decades.
- What are the possible impacts climate change on malaria elimination efforts?
- Additionally, there are other climate-sensitive infectious diseases.

Key questions

- What are the climate change/variation impacts on infectious diseases?
- What are the possible impacts of changing climatic patterns on malaria elimination efforts?
- What are the impacts of other non-climatic, but equally important factors?

Devastating cyclones and droughts

SOUTHERN AFRICA
Impact of El Niño in Malawi, Zambia, and Zimbabwe

acaps | Briefing note 06 May 2024

CRISIS OVERVIEW

Southern Africa is currently struggling with the effects of El Niño, characterised by temperatures and precipitation anomalies that have been resulting in floods, droughts, heatwaves, and below-average rainfall (OCHA 19/04/2024). These have significantly affected livelihoods, agriculture, and food security across several countries. In 2023, Southern Africa faced high food insecurity levels. The subsequent failed rainy season (October–March) in most countries in the region aggravated existing vulnerabilities, such as food insecurity, water scarcity, and health risks (FAO 23/04/2024; OCHA 19/04/2024).

Malawi, Zambia, and Zimbabwe have all declared states of disaster as they experience the worst droughts in decades (Malawi 24 23/03/2024; STC 03/04/2024; AP 04/04/2024). El Niño-induced weather patterns in these three countries have led to below-normal rainfall, crop losses, and widespread food insecurity (FAO 23/04/2024; OCHA 19/04/2024).

Malawi

The rainy season produced normal to below-average rainfall, with episodes of heavy rains in some parts of the country. The rainy season normally runs from October–March but was delayed in 2023 by the effects of El Niño

year (Africanews 25/03/2024; WB accessed 11/04/2024 a; WB accessed 11/04/2024 b). Between October 2023 and March 2024, an estimated 4.4 million people (22% of the total country's population) faced Crisis (IPC Phase 3) or worse food insecurity levels (IPC 18/08/2023).

Zambia

The climate effects of El Niño have contributed to the mid-season dry spell in Zambia, affecting seven out of ten provinces as at early April 2024 (STC 03/04/2024). The provinces facing the most impacts are Central, Eastern, Lusaka, North-Western, Southern, and Western (IFRC 02/03/2024; STC 03/04/2024). The below-average 2023–2024 rainy season and consequent drought affected about 1 million hectares (2.5 million acres) of the 2.2 million hectares (5.4 million acres) planted with maize, a staple food crop in the country (Lusaka Times 01/03/2024; STC 03/04/2024). Between October 2023 and March 2024, about 2.04 million people (23% of the analysed population) were projected to face IPC 3 or worse food insecurity levels (IPC 13/11/2023).

Zimbabwe

Because of the El Niño-induced drought, more than 80% of the country received

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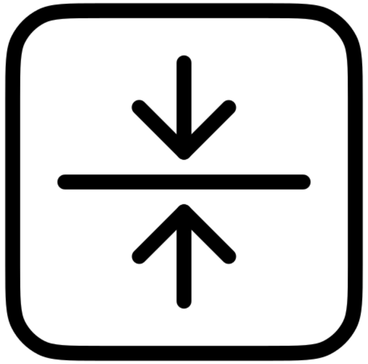
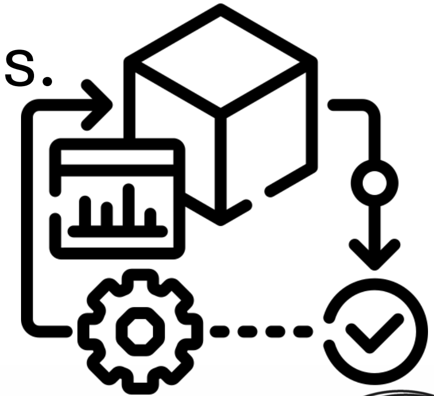
Approaches to addressing impacts in Malawi

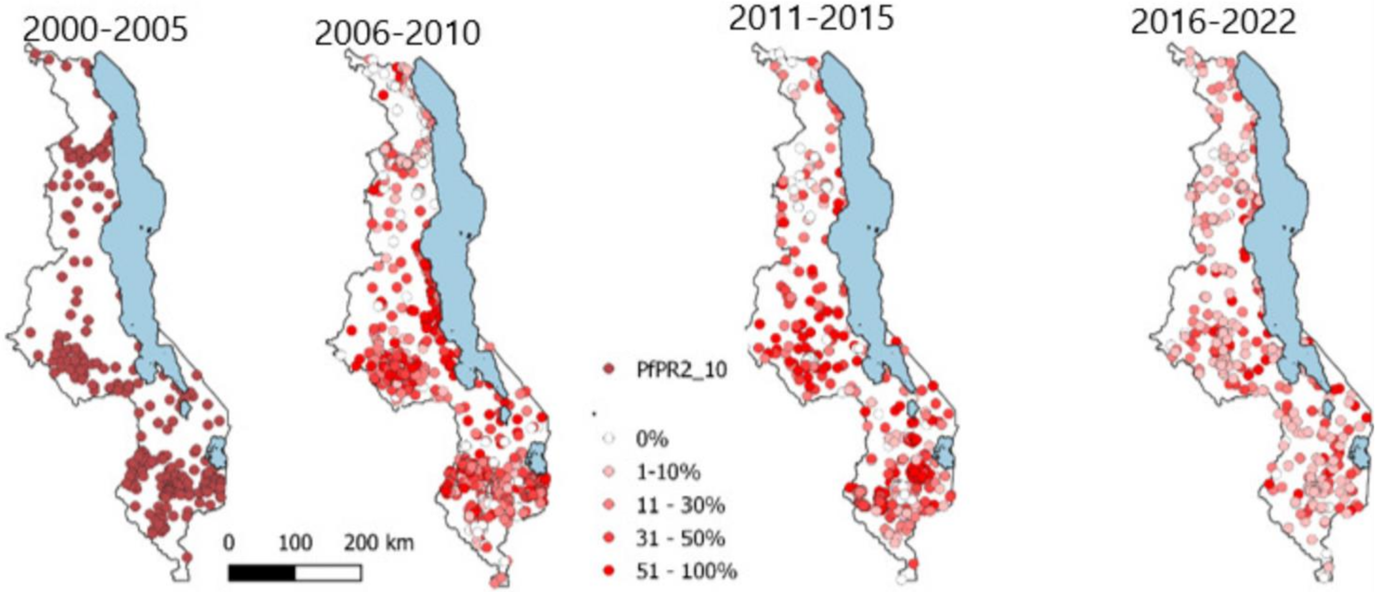
- Gather disease data.
- Statistical approaches to understand the burden.
- Modelling to predict prevalence at unobserved locations.
  - Include climatic and environmental factors.
- Conduct stratification to sub-district level.

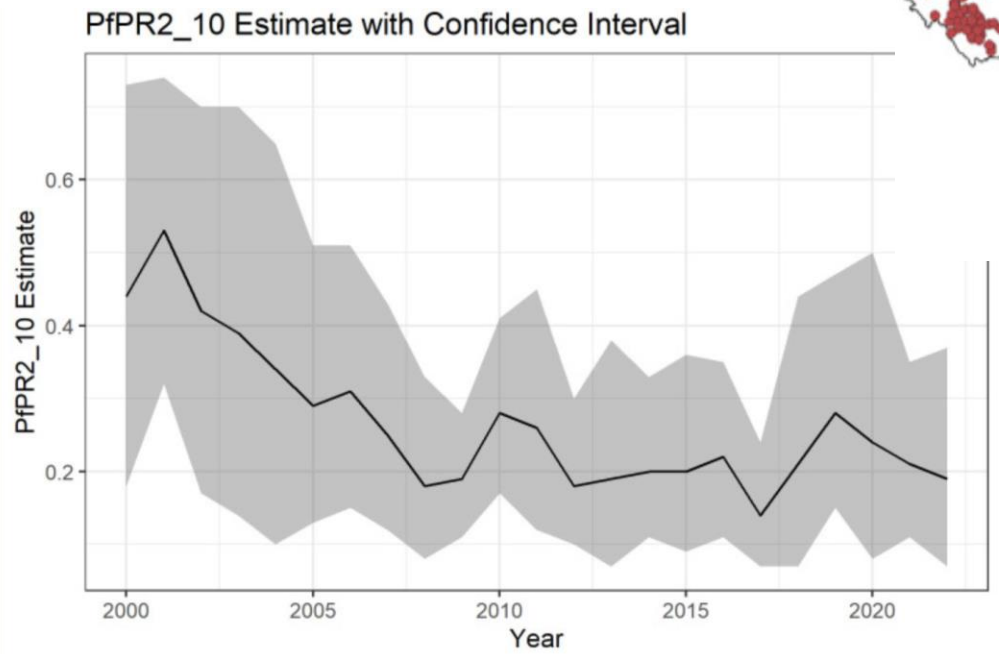




Malaria in Malawi

Modelling to understand malaria landscape





Wellcome Open Res. 2024 Jan 8:8:264. doi: 10.12688/wellcomeopenres.19390.2. eCollection 2023.

Two decades of malaria control in Malawi: Geostatistical Analysis of the changing malaria prevalence from 2000-2022

Matugula, et al, 2023

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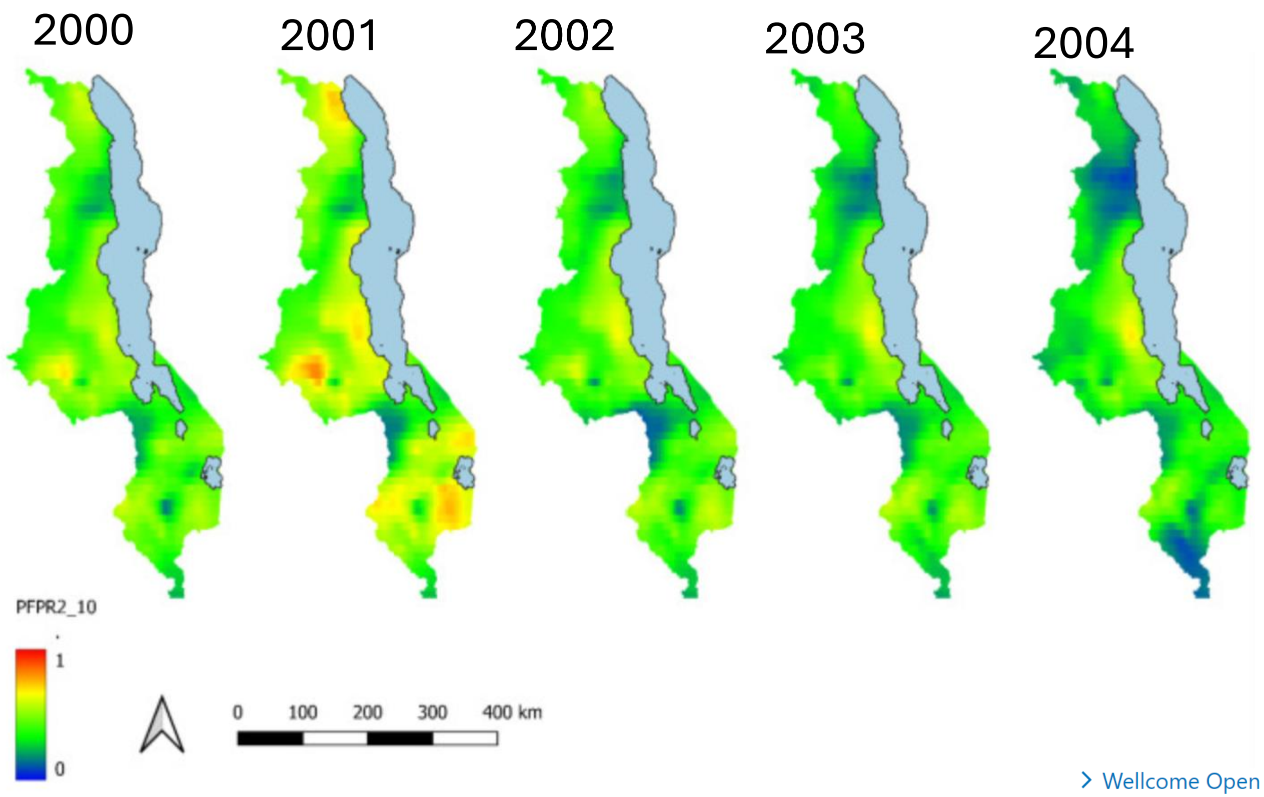
Modelling to understand malaria landscape



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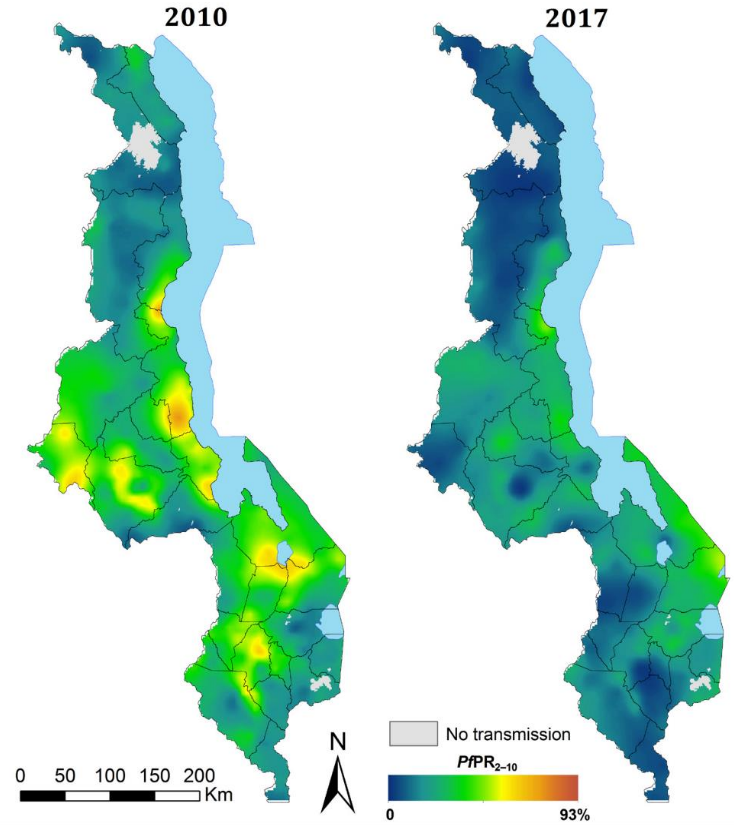

> Wellcome Open Res. 2019 Jul 4:4:57. doi: 10.12688/wellcomeopenres.15193.2. eCollection 2019.

Geostatistical analysis of Malawi's changing malaria transmission from 2010 to 2017

Chipeta M, et al, 2019

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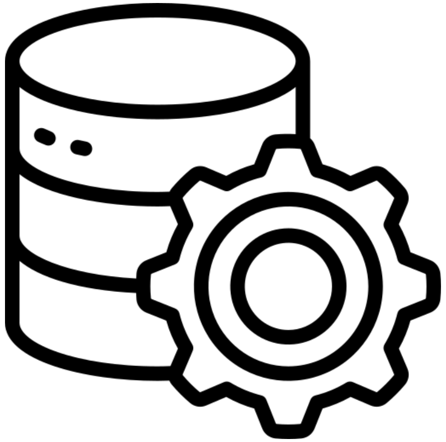
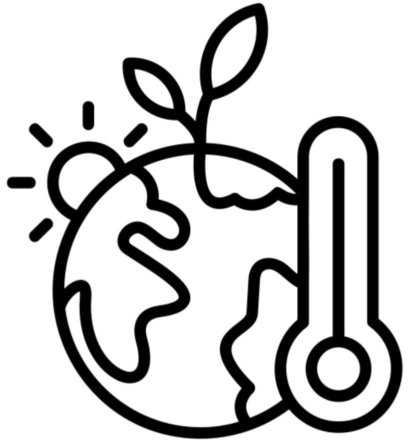
What have we observed?

- Declining malaria
- Hotspots revealed
- Changing climatic conditions
- Changing socio-demographic and environmental conditions.

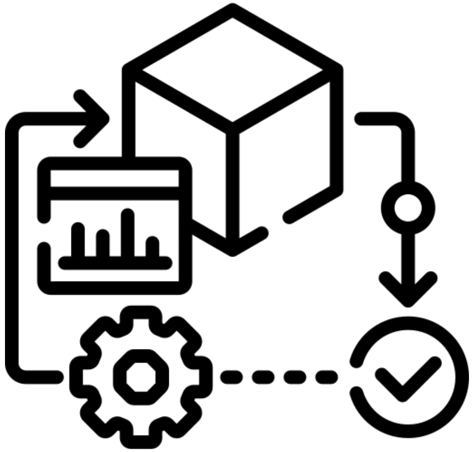
Steps in statistical analyses



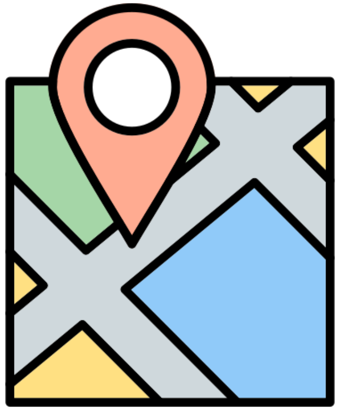
Data spanning many years



Climatic variables



Spatio-temporal modelling



Risk mapping

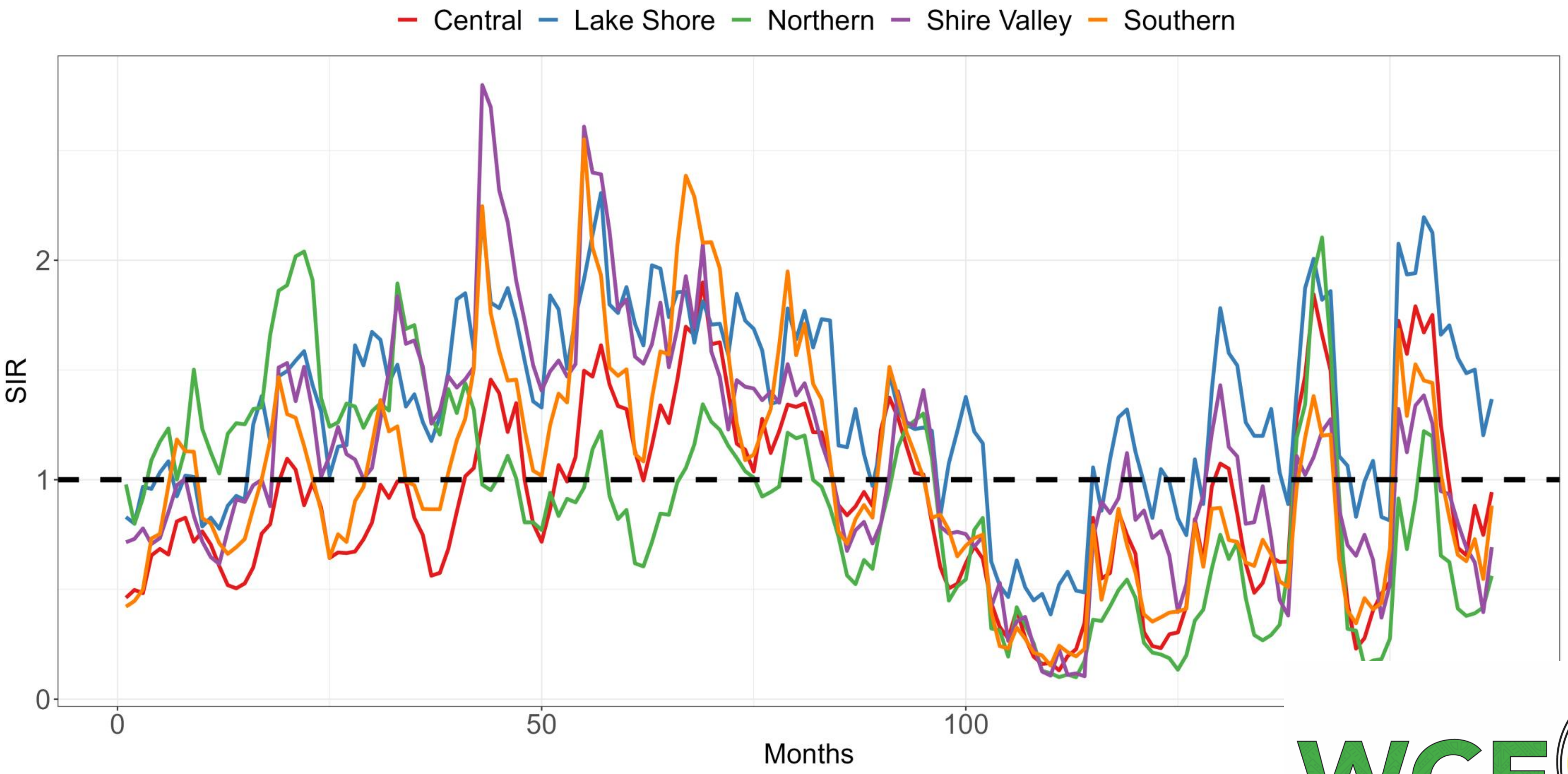
Methods

Binomial or Poisson/Negative binomial distribution.

Bayesian spatio-temporal models.

Map smoothed estimates.

Temporal changes in malaria



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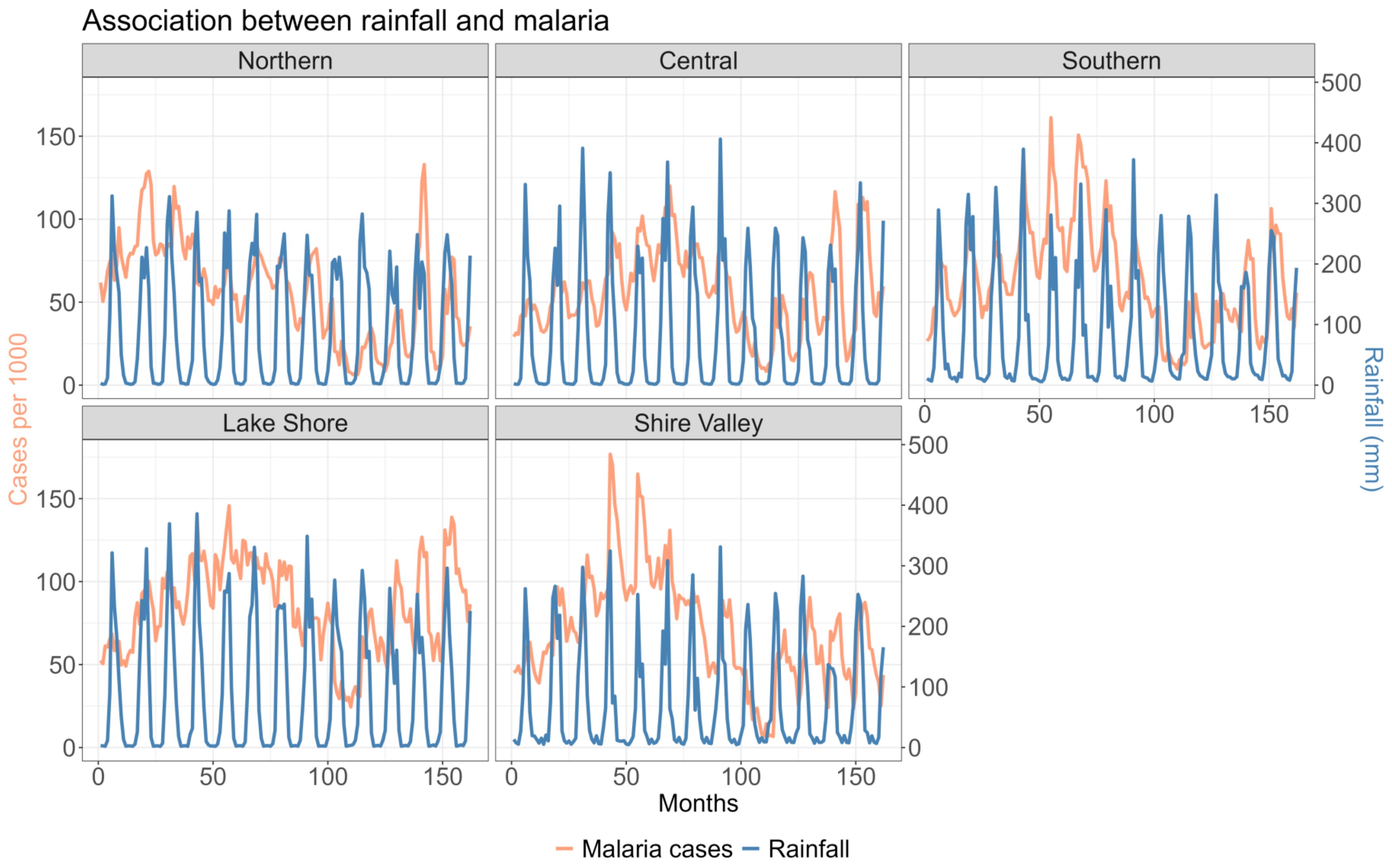
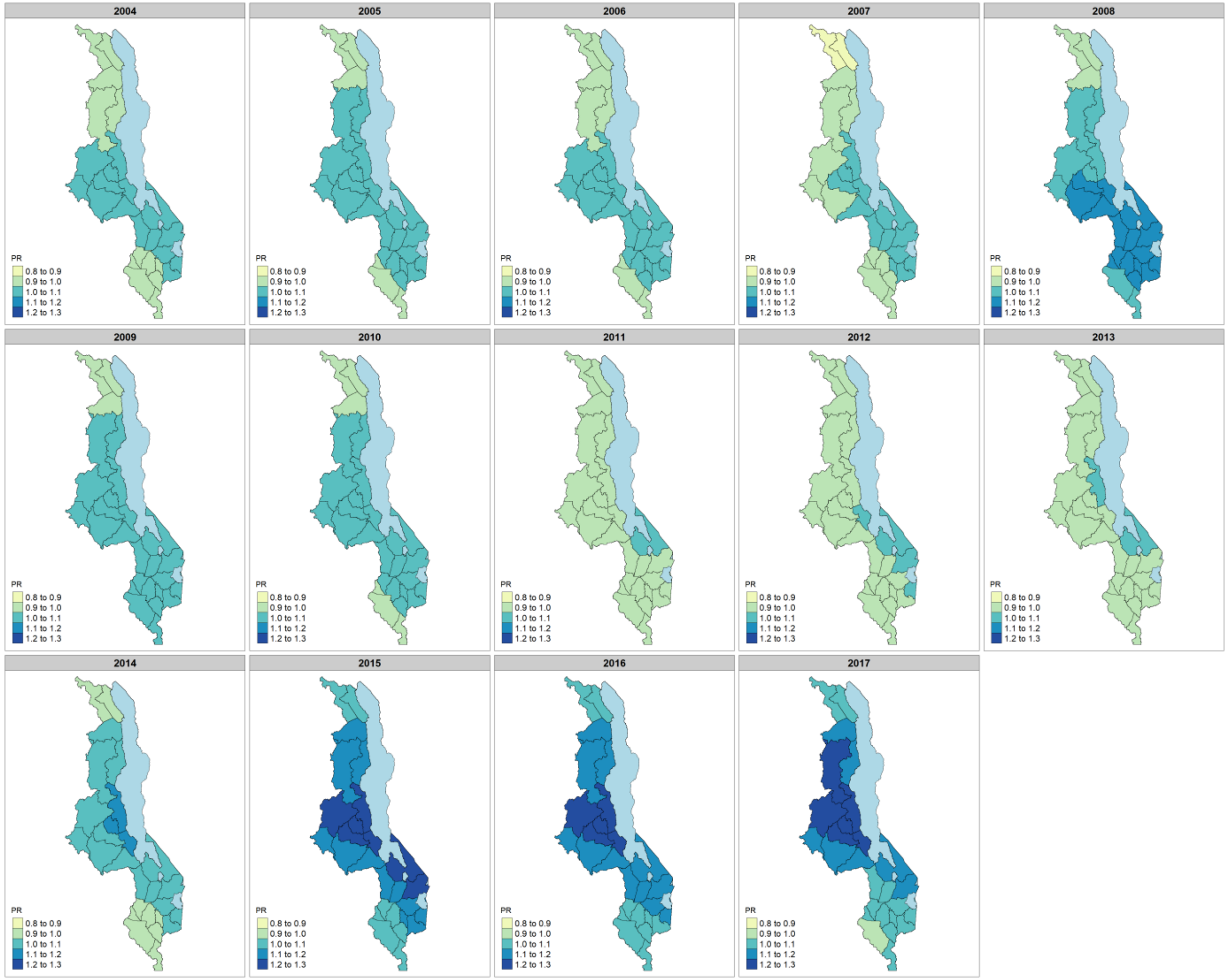
Malaria and rainfall



Spatial changes in risk



- Risk explained by rainfall and temperature.
- Heterogeneties at district level.

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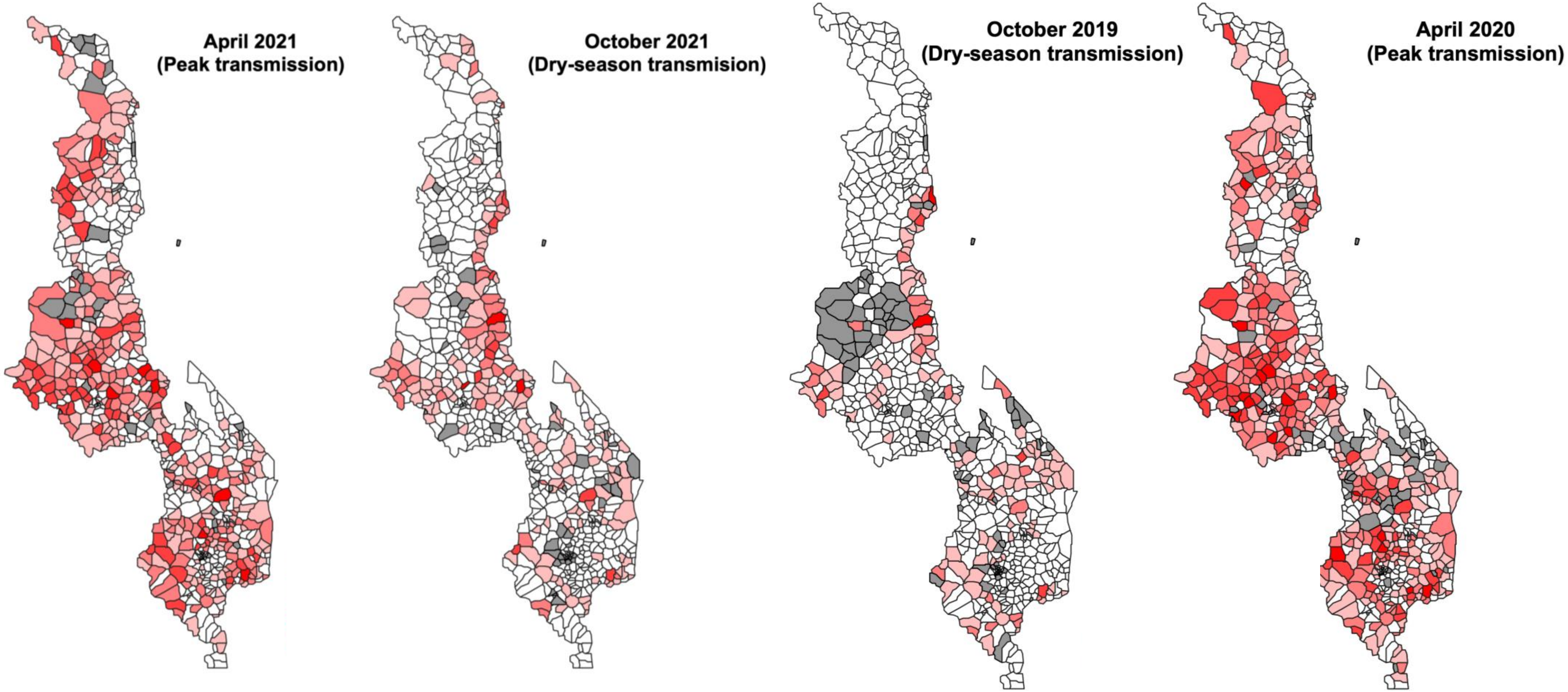
Malaria burden stratification

- Stratify malaria burden at district and sub-district level.
- Reveal heterogeneities.
- To provide actionable classifications as elimination target approaches.
- **Develop facility catchment areas** as spatial units for understanding sub-district heterogeneity.

Snapshot of stratification work



Manuscript under preparation

Cholera in Malawi

Cholera outbreaks

- Uncharacteristic outbreaks.
- Not restricted to rainy season.
- Most districts affected.

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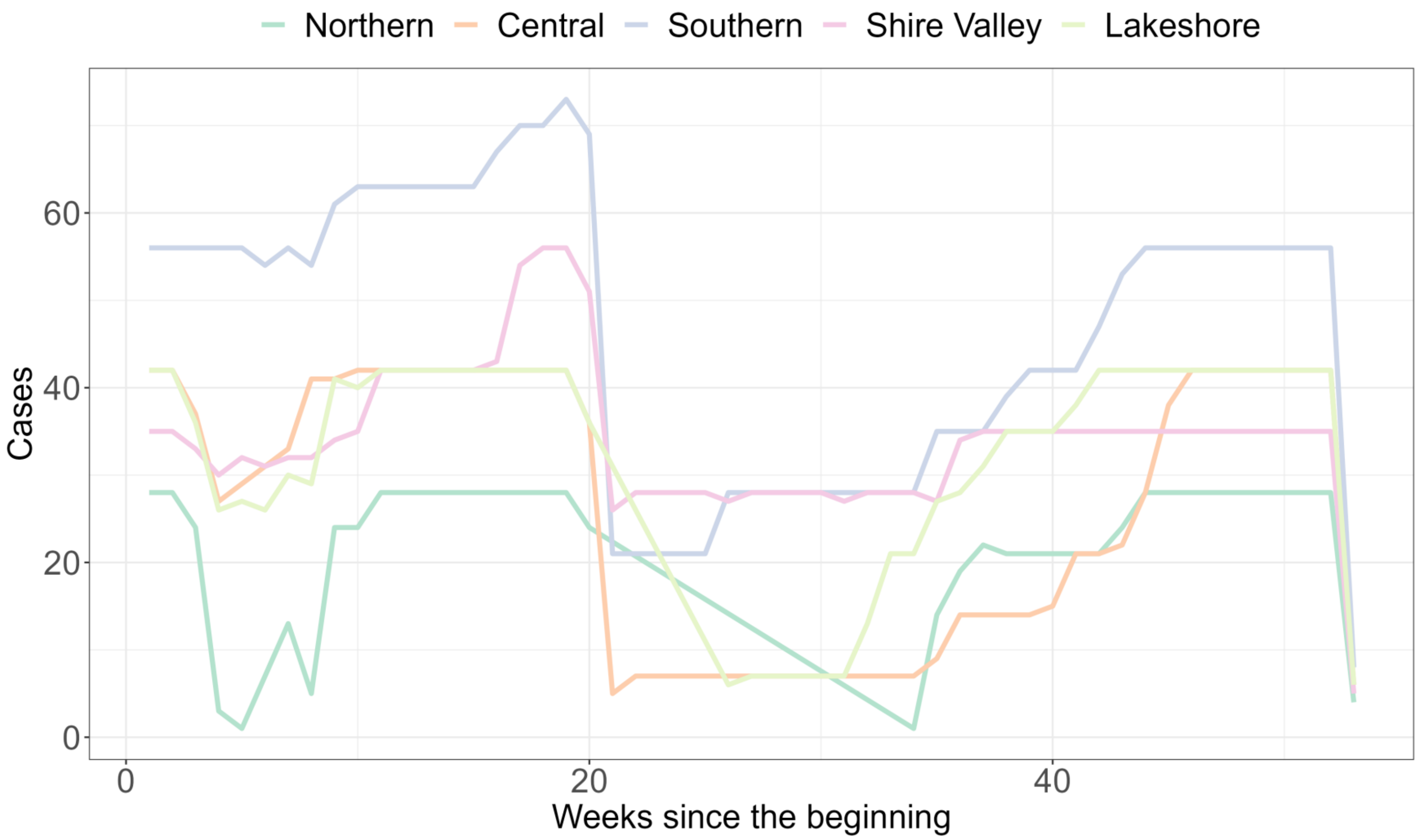
Cholera outbreaks



Transmission sustained for over 2 years

Work on cholera

- Geolocating hotspots.
- Spatio-temporal analysis.
- Data dashboard.
- Modelling
  - Interrupted time series.
  - Zero-inflated models – with climatic variables.

Future steps

- Model changes in malaria at the sub-district level.
- Modelling for mapping cholera risk.
- Incorporate climate variables in the models.
- Develop digital tools for use in surveillance

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