SPEAK India:
Mathematical & Statistical Modelling

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Setting the Post-Elimination Agenda for Kala-azar in India

Aims

- Statistical modelling
  - Develop short-term prediction approaches to support management of elimination
  - Support capacity development in India
- Mathematical modelling
  - Transmission dynamic processes (space, vectors etc)
  - Identify barriers to zero transmission (proper elimination)
  - Define a minimum set of population measurements to estimate population risk

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Block-level Forecasting

1. Use routinely collected case data (KA-MIS) for short-term prediction of block level incidence (~3-4 months ahead of current data)
   - Spatiotemporal statistical model
   - Produce an expected range for future months according to the block-specific historical patterns
   - Highlight where blocks may be deviating from the overall trend
2. Use VL case and environmental covariates data for predicting block level risk of resurgence
   - Spatiotemporal statistical model
   - Identify the determinants of risk of resurgence
   - Predict block level risk of resurgence using INLA (Integrated Nested Laplace Approximation)

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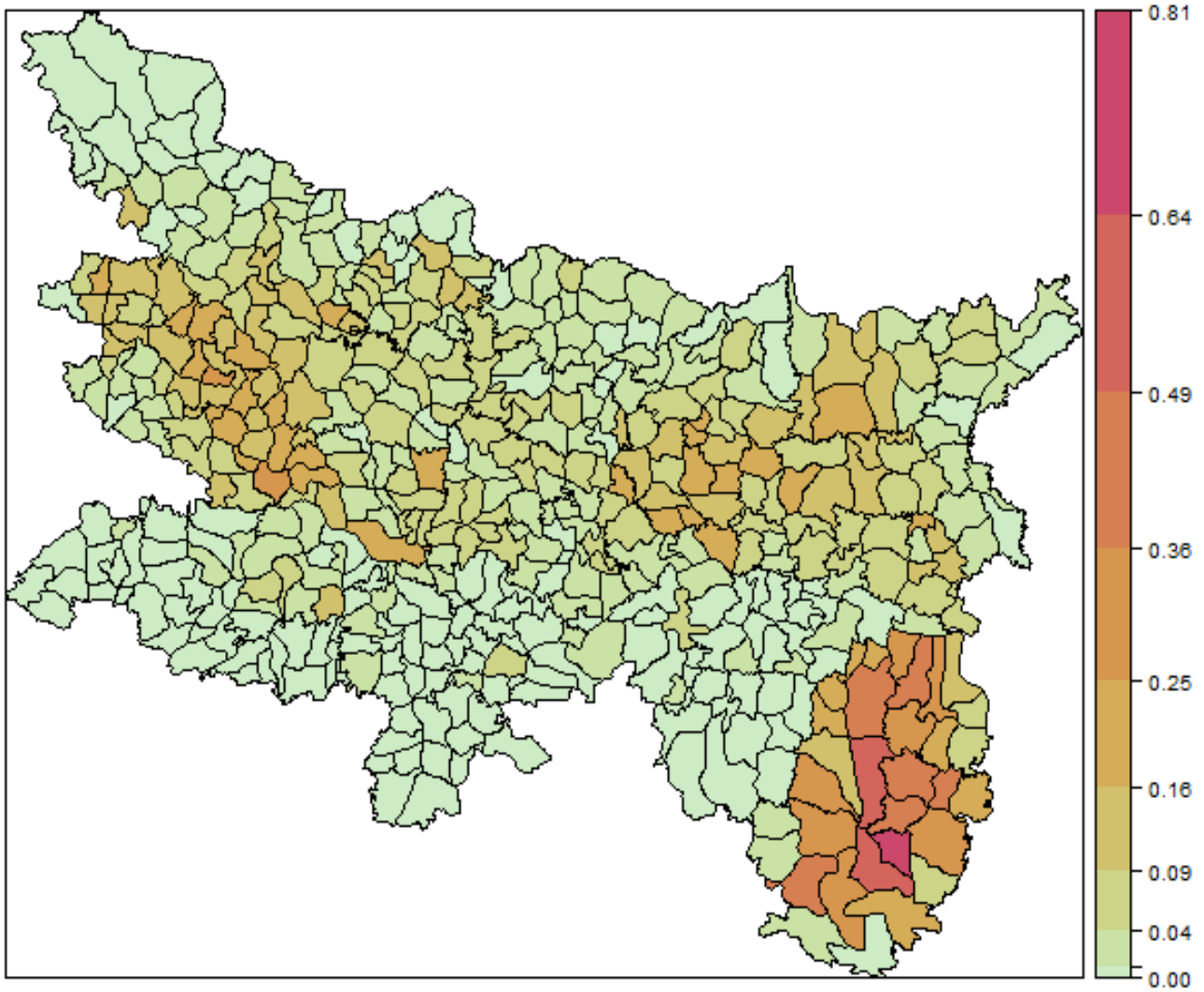
1. Short-term prediction of block-level incidence

Average monthly block-level incidence 2013-2018



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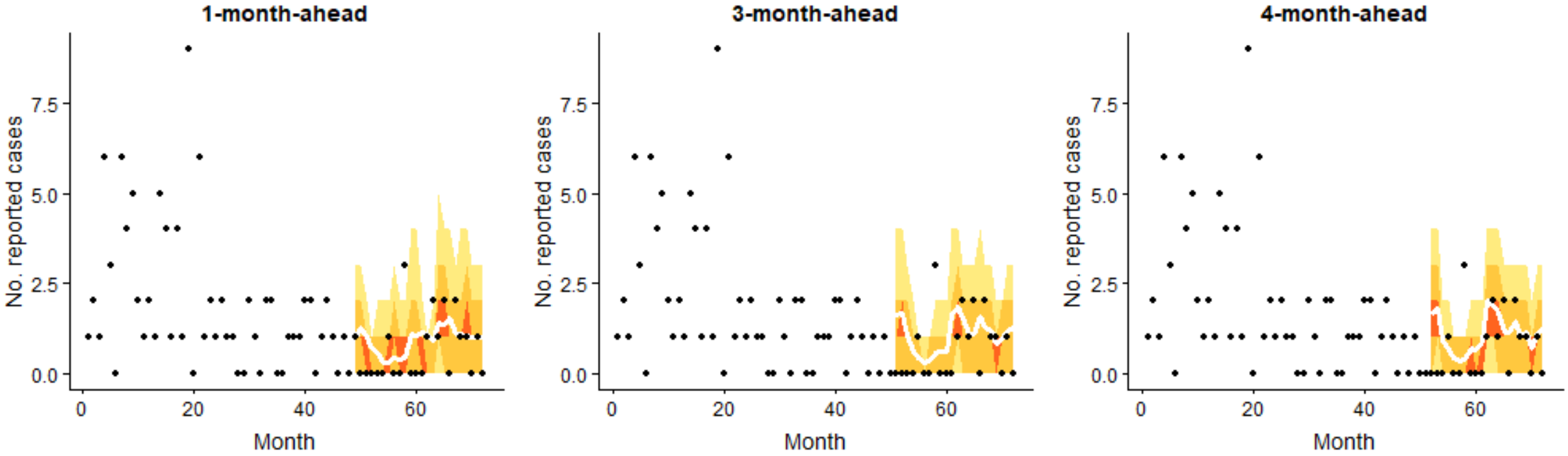
- Current model has good predictive power at least **four months ahead** of current data.
  - **93%** of predicted points were **within +/-2 cases** of the observed count, when predicted four months ahead of the training data.
  - **85.6%** of observations in the test period were captured in the **25-75% prediction interval**.
  - **94.7%** were captured in the **10-90% prediction interval**.
- Identified model limitations and considered how these could be addressed in next steps
- Used model to demonstrate that current target is unlikely to be met to inform discussions on 2030 target setting at WHO STAG meeting
- Proposed alternative target and tested its performance using predictions from the model

Next steps:

- Investigate village-level dynamics ("micro-outbreaks") to better understand block-level incidence

Short-term predictions

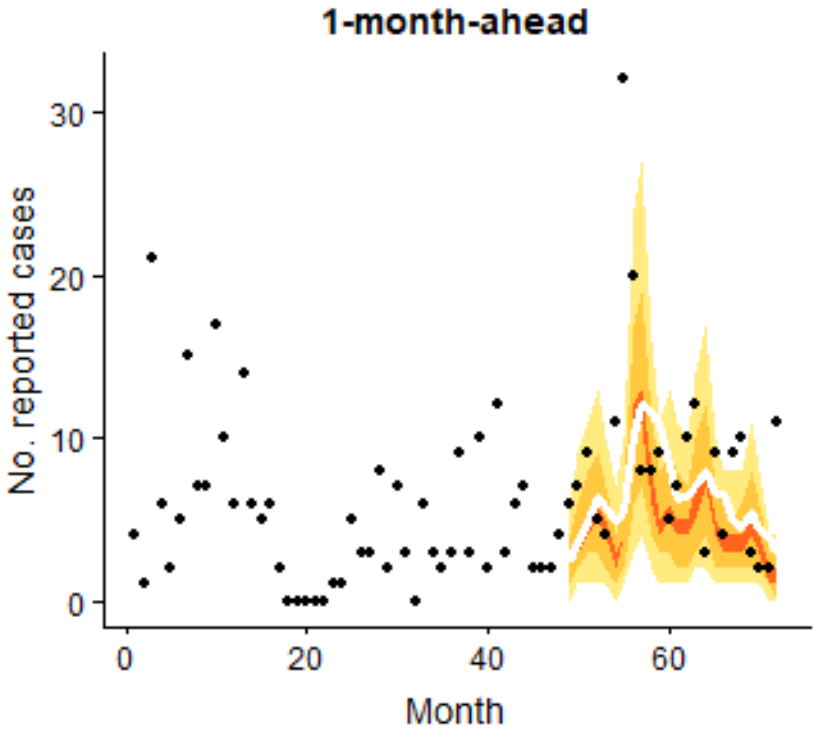
JALALPUR, BIHAR

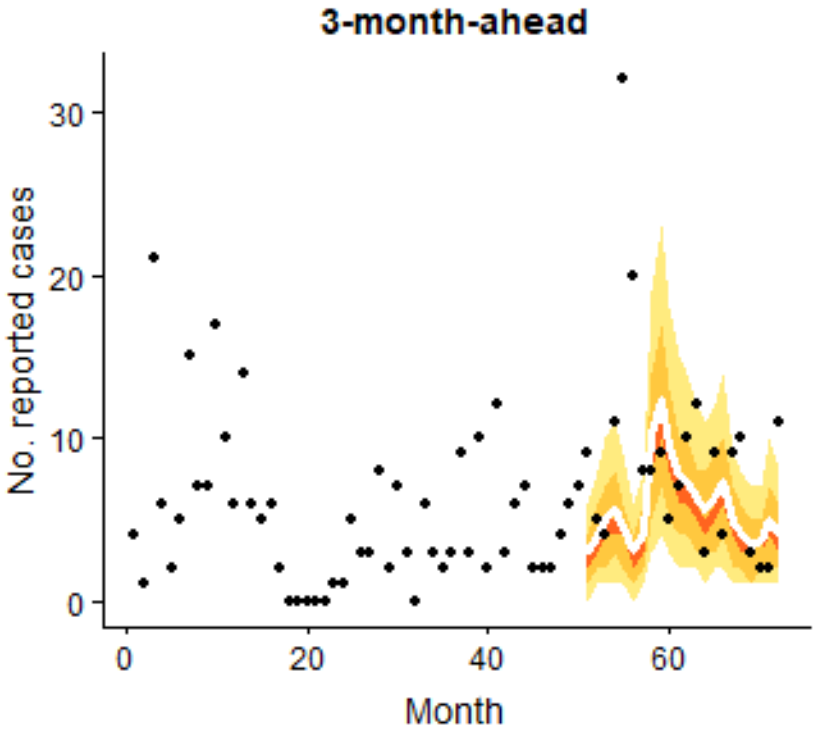


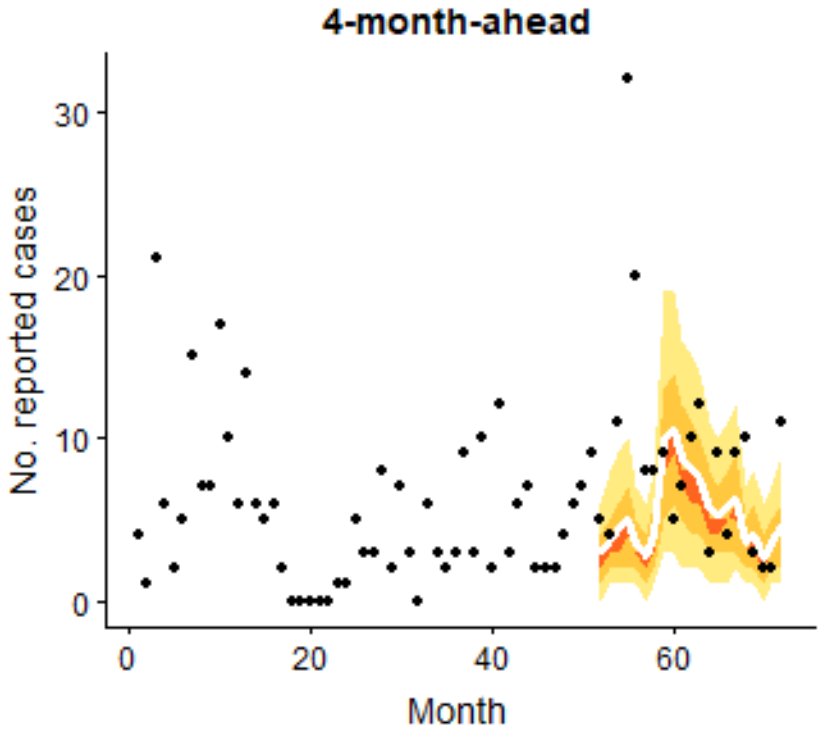
Central 10%, 50% and 80% prediction intervals (illustrated by red, orange and yellow bands) from a model fitted to training data from January 2013 to December 2016 (4 years, months 1-48). The mean (expected) case count is indicated by the white line.

Short-term predictions

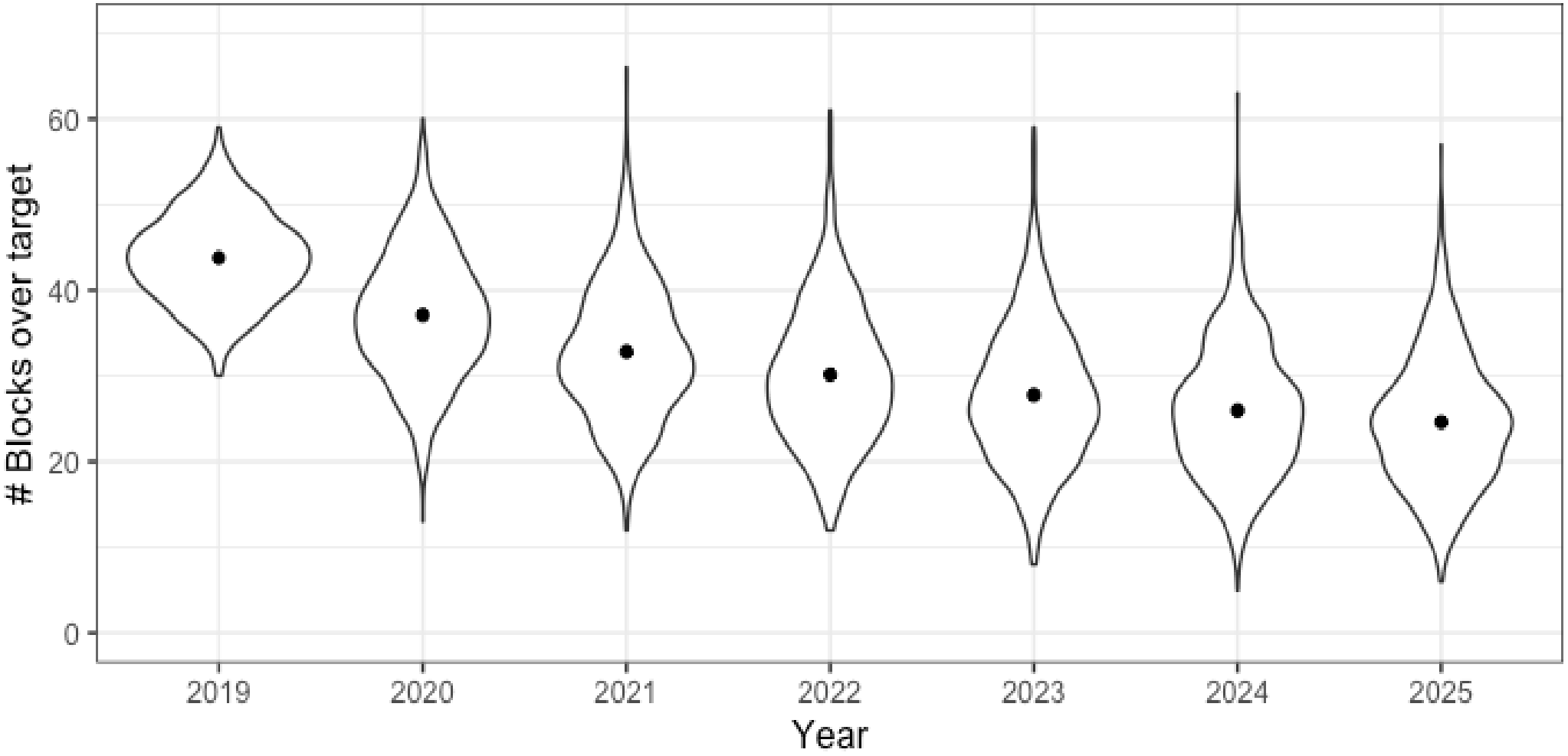
PAKUR, JHARKHAND





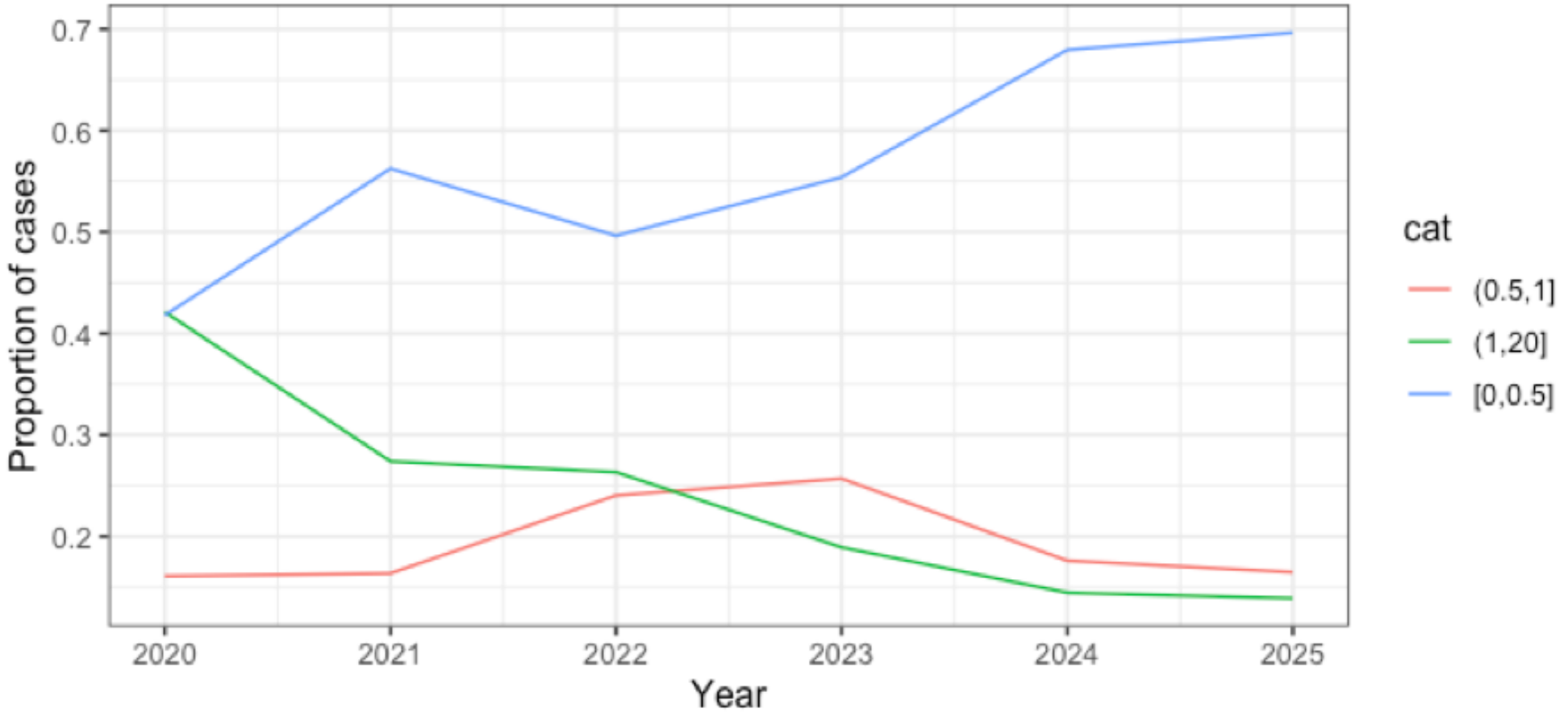


Predictions for elimination target



Elimination target (incidence in all blocks <1/10,000/yr for 3 years) very unlikely to be met by 2020 or 2025

Predictions for alternative target



Proportion of cases coming from blocks with low incidence in the previous year (<0.5/10,000/yr) has increased and should continue to increase to 70% by 2025 if interventions are maintained

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2. Predicting block level risk of resurgence

Progress:

- Developed methods for extracting climatic and environmental covariates data

- Extracted monthly data for 19 bio-climatic and 4 environmental covariates for all the 534 blocks (endemic / non-endemic) in Bihar for the period from Jan 2013 to Dec 2019.

Next steps:

- Extraction of covariates data for blocks in Jharkhand, UP and West Bengal
- Modelling association of VL cases with covariates, and predict block level incidence using INLA

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Transmission Dynamics

Progress:

- Reviewed the work on modelling sand fly population dynamics and ecological modelling, and the assumptions and structure of the models
- Developed individual-level spatial kernel transmission model for VL
- Estimated contribution of PKDL cases to transmission
- Fitted to geolocated individual-level data from Fulbaria, Bangladesh (Caryn Bern), and PKDL infectiousness data from xenodiagnosis study in Bangladesh (Dinesh Mondal, Jorge Alvar)

Next steps:

- Model the transmission dynamics in human-parasite-vector
- Complete work to include asymptomatic infection and immunity from asymptomatic infection in the model
- Simulate spatially and temporally targeted control interventions
- Apply the model to identify the 'minimum surveillance set' data and evaluate potential changes to interventions

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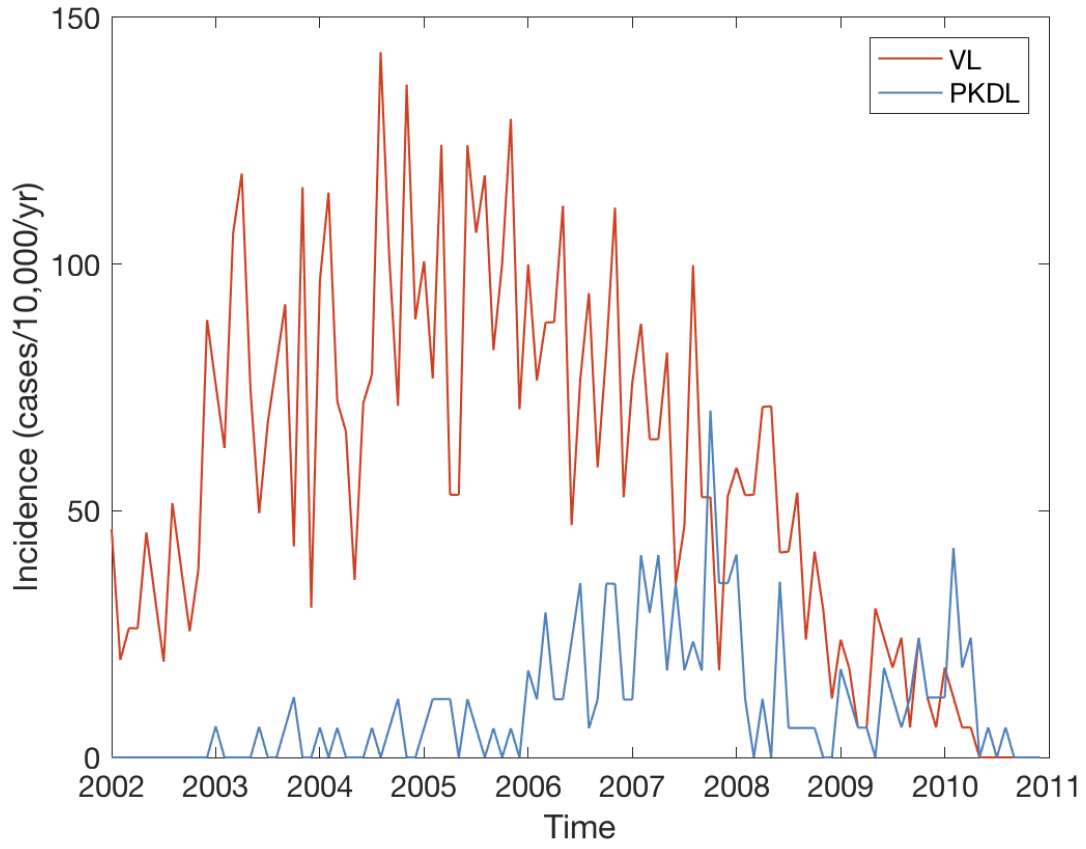
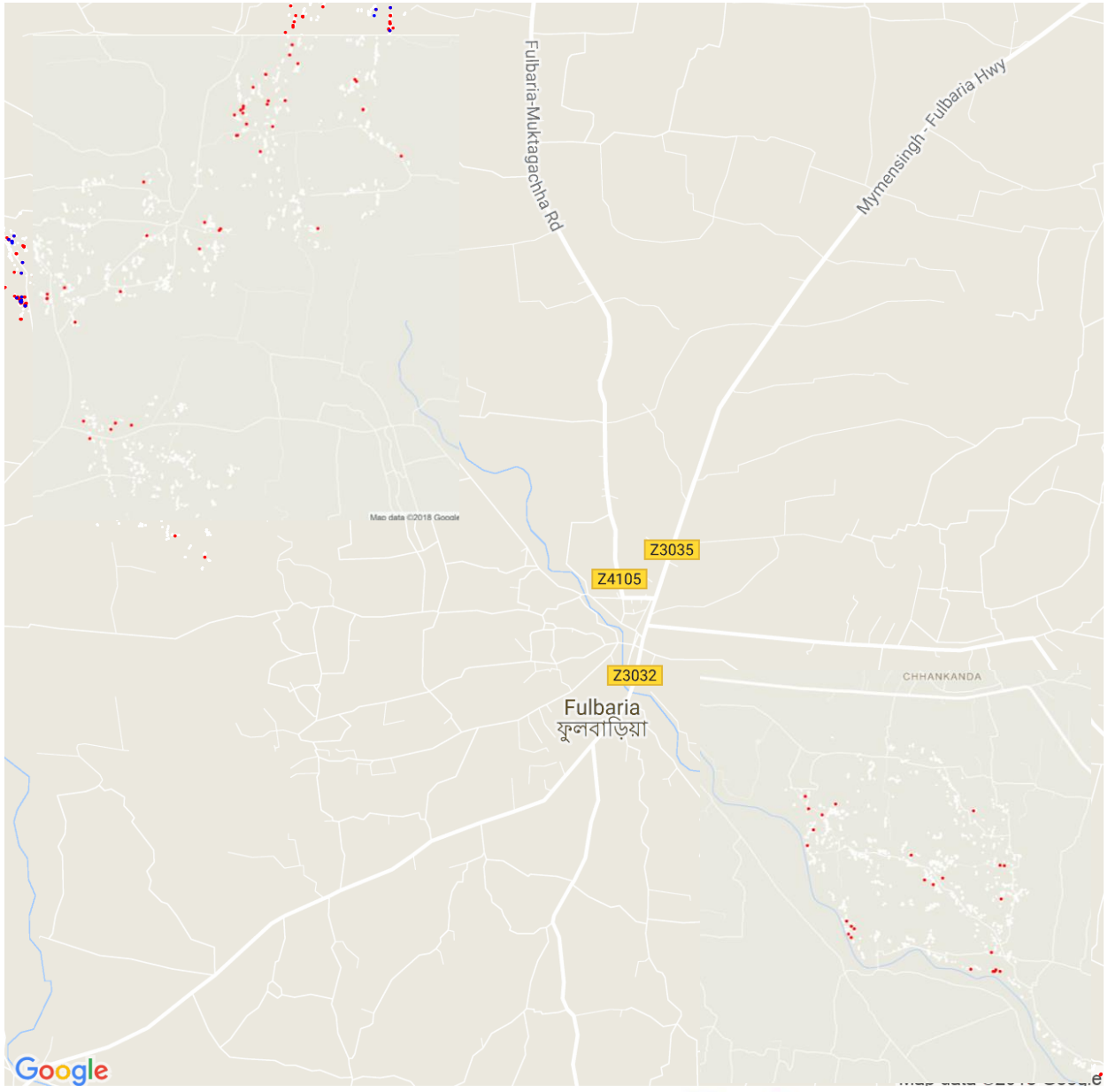
Data

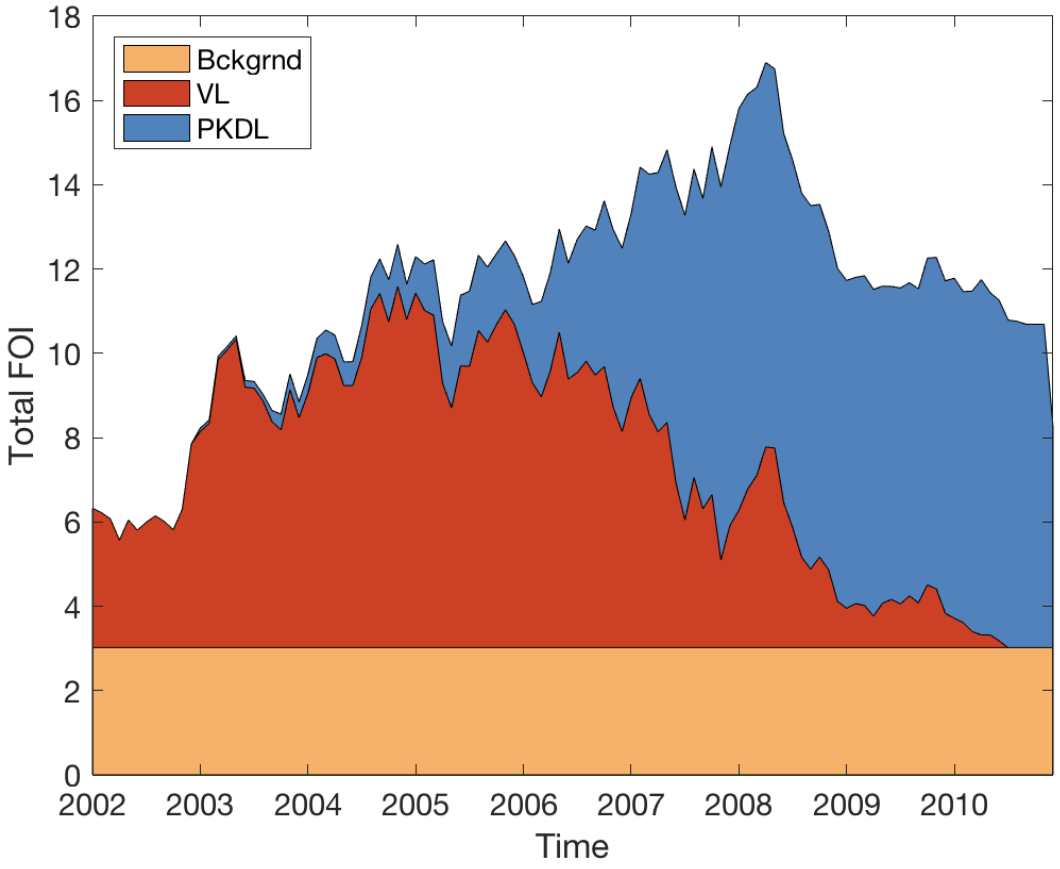
Fulbaria, Bangladesh 2002-2010





Contribution to transmission

Contribution to infection of sandflies



Contribution to infection of new cases