

One Step Ahead: Predicting Antimicrobial Resistance from Geographic Variables in India

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Introduction

- **Antimicrobial Resistance (AMR):** pathogens resistant to antibiotics
- Without effective antibiotics, many vital procedures cannot be done^[1]
- AMR threatens modern medicine
- **Perplexingly, many AMR infections are Hospital Acquired (HA): patient acquires infection when seeking care**

Purpose

- **India** is a hotspot of HA AMR^[2]
- Mitigating HA AMR requires **identifying HA AMR burden**^[3]
- **Goal: Predict HA AMR burden in India at a 1 km scale based on geographic variables**
- Will allow researchers/policymakers to identify HA AMR hotspots → implement policies for mitigation

Methods: Overview

1. Obtain current HA AMR burden data
2. Obtain geographic data
3. Develop predictive model
4. Interpret results from model

Data

1. Current HA AMR burden: 2010 – 19
 - a. Literature search: 15 studies, 30 sites with HA AMR data^[4]
 - b. Test different antibiotics & bacteria
 - c. → Burden = “**P50**”: % of tests with >50% of bacteria resistance^[5]
2. Geographic data:
 - a. Open-access data collected^[6]

Results

HA AMR Burden: Geography

- P50 values at sites → interpolate over *all* of India
- **First map of local P50: geographic insight**
- **However, interpolated map does *not* estimate P50 according to geographic trends (ex., population, urbanicity, GDP, etc.)**
- Identify geographic variables to predict P50: develop predictive model for P50

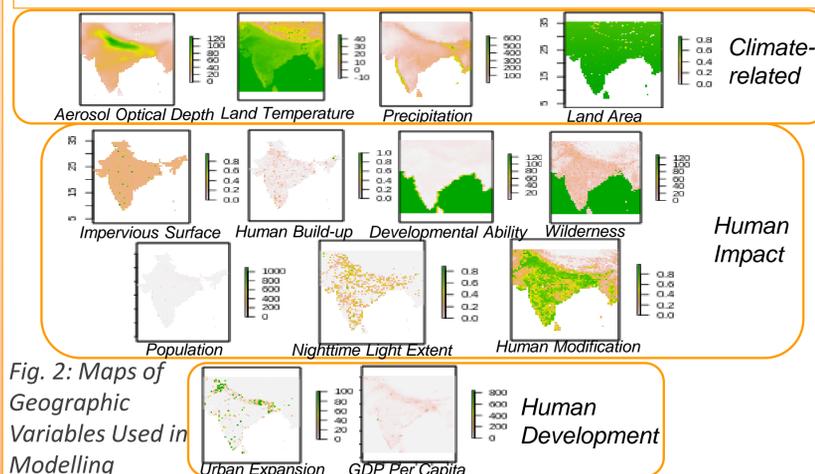


Fig. 2: Maps of Geographic Variables Used in Modelling

Predictive Model Development

- Predict P50 using linear regression with all 13 vars
- However, two problems arise with model:
 - Predicts P50 values > 1 and < 0 – impossible
 - Predictions not fixed to have average P50 estimate equal to established average of P50 over all of India^[8]
- Quasi-linear adjustment to model predictions
 1. Apply sigmoid function – fixes average & constrains P50 from 0 to 1
 2. Average interpolated map and sigmoid output – ensures proper geography of estimates
- **P50 estimates from 0 to 1, consistent with established data**
- **R² of 66.8%**

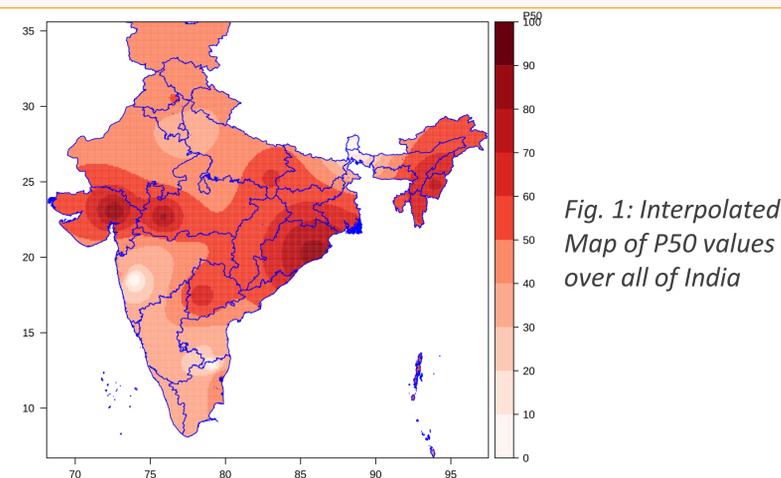


Fig. 1: Interpolated Map of P50 values over all of India

Geographic Variables

- Many possible predictors: HA AMR = complex
 - Health-related, climatological, human-related
- Health-related data is **not** open-access, and poorly correlates with HA AMR^[7]
- Instead, need **proxies** for antibiotic abuse & HA AMR spread
- 13 variables: 4 climatological; 7 human impact; 2 human development related

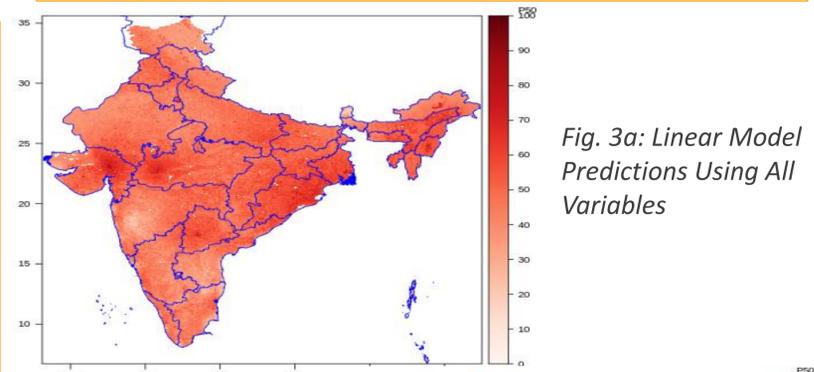
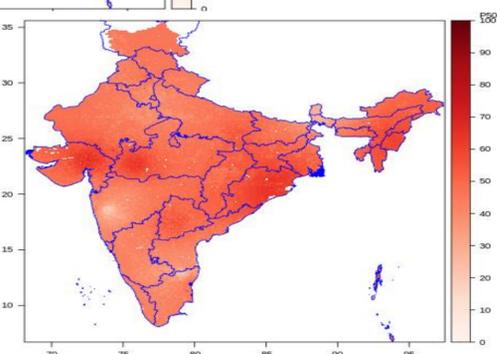


Fig. 3a: Linear Model Predictions Using All Variables

Fig. 3a: Linear Model Predictions Using Impervious Surface Build-up and Nighttime Light Extent



Discussion

Insight from variable importance:

- Two variables together have R^2 of 30%:
 1. Impervious surface build-up
 2. Nighttime light extent
 - Measures of urbanicity/impact
 - Simple **proxies** for HA AMR burden

Insight from maps over *all* of India:

- **High burden everywhere**
- Need extreme rural for low P50
- Development has little impact on P50 → HA AMR is a concerning and endemic issue in India that cannot be fixed without improving public health

Looking Ahead

- First map of local HA AMR burden in India from geographic variables
 - 1 km resolution; R^2 of 66.8%
- Key variables: imperviousness and nighttime lights
- Key insights:
 - **Use maps to implement policies for HA AMR mitigation in key locations**
 - **Critical for public health & safety**

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- [1] <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>
- [2] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6563732/>
- [3] https://www.who.int/foodsafety/areas_work/antimicrobial-resistance/amr_tripartite_flyer.pdf?ua=1
- [4] For a list of released papers, please email ckkumar@Princeton.edu
- [5] <https://science.sciencemag.org/content/365/6459/eaaw1944>
- [6] <https://sedac.ciesin.columbia.edu/data/sets/browse>
- [7] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4364737/>
- [8] <https://resistancemap.cddep.org/>