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

   a. Literature search: 15 studies, 30 sites with HA AMR data[4]
   b. Test different antibiotics & bacteria
   c. **Burden = “P50”:** 96% 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

**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

**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%**

Discussion

Insight from variable importance:

- Two variables together have R² 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

Looking Ahead

- First map of local HA AMR burden in India from geographic variables
- 1 km resolution; R² 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

Acknowledgements

I would like to thank Ruchita Balasubramanian (’19) and Dr. Ramanan Laxminarayan for their mentorship throughout this project. I am grateful to the Center for Health and Wellbeing for funding this incredible experience.

[3] https://www.who.int/foodsafety/areas_work/antimicrobial-resistancenestam帝国_07279_4f09a5_24f5a4_14a4
[4] For a list of released papers, please email chikumar@princeton.edu
[5] https://science.sciencemag.org/content/365/6459/eaaw1944
[6] https://data.oxdce.ac.uk/data/sets/detail/antimicrobial-resistance/amr_tripartite_flyer.pdf?ua=1
[8] https://www.who.int/health-topics/amr/modeling?language=en

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