The SaniPath Approach to Fecal Exposure Assessment and Application to Typhoid Transmission

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SaniPath

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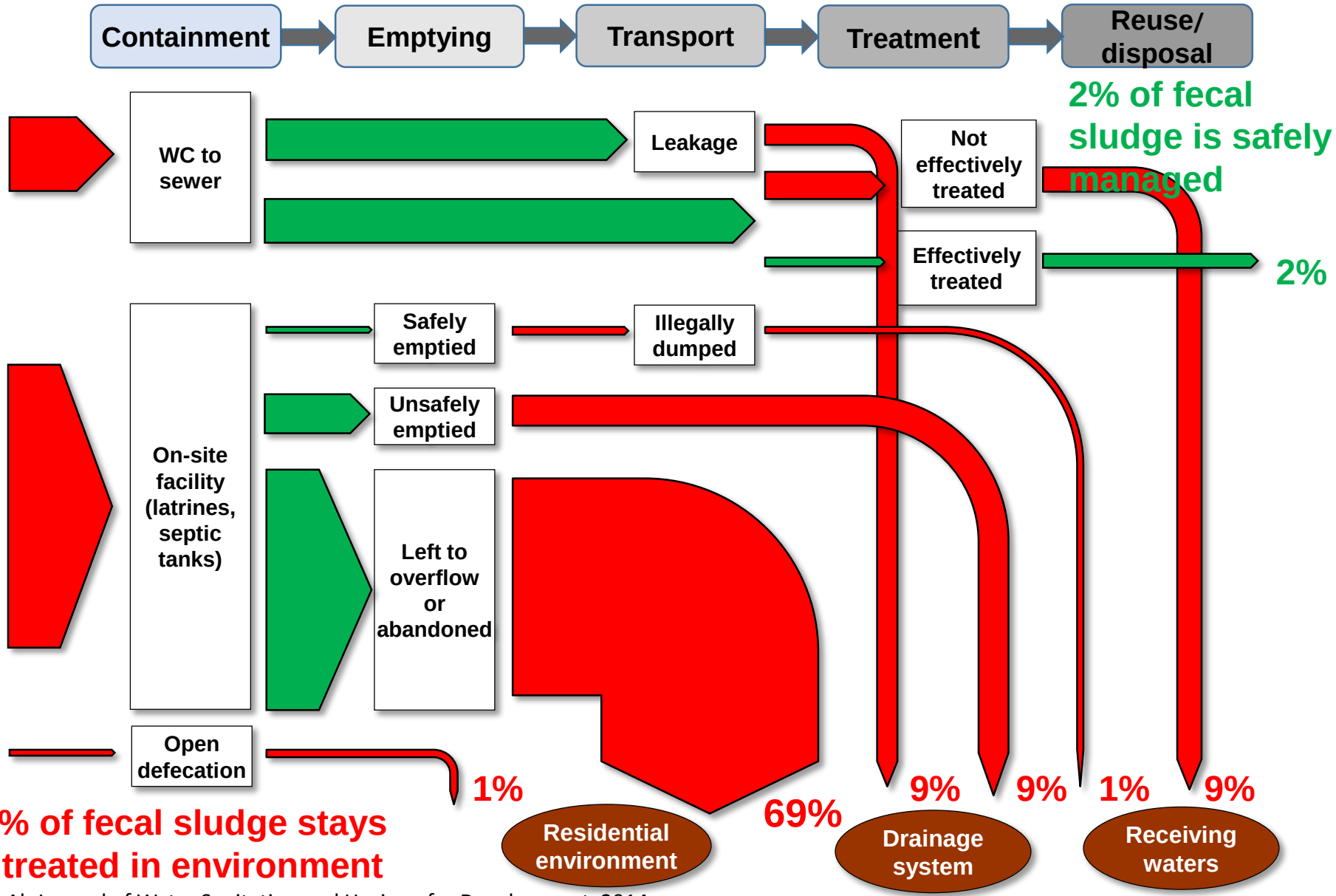
Overview

- Urban sanitation is not just about household toilets but also needs to consider where the ‘fecal sludge’ ends up. Children in low-income neighborhoods may be surrounded by shit
- SaniPath approach for assessing exposure to fecal contamination in the urban environment
- SaniPath adaptation for *S*. Typhi and *S*. Paratyphi A – valuable for advocacy and to guide intervention investments

Shit Flows Analyses show that Fecal Sludge is NOT Contained – Reservoirs in Urban Environment



Peal et. Al. Journal of Water Sanitation and Hygiene for Development. 2014

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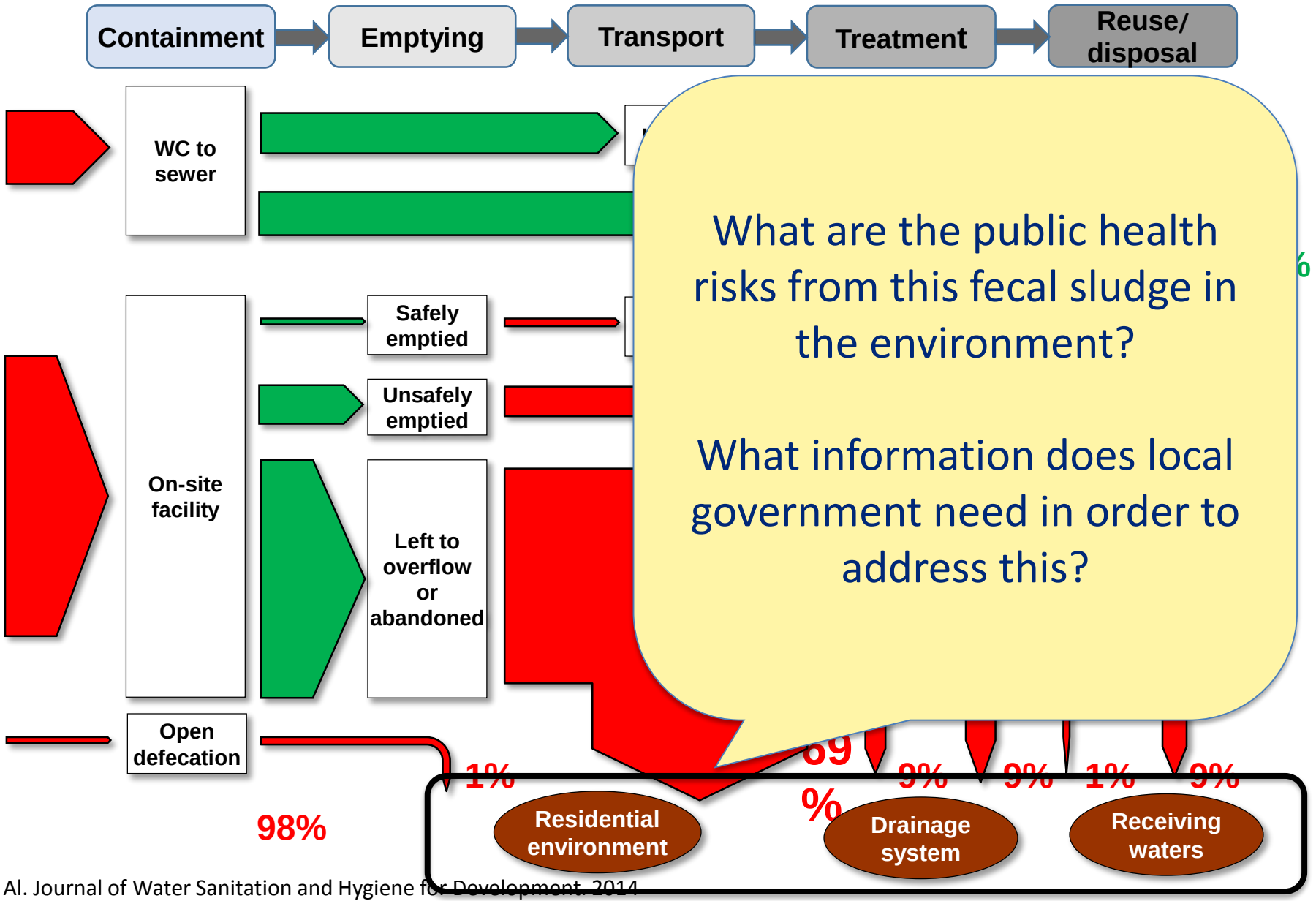

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Pathways of Exposure to Fecal Contamination - Urban

Floodwater

Public latrines

Open drains

Surface water

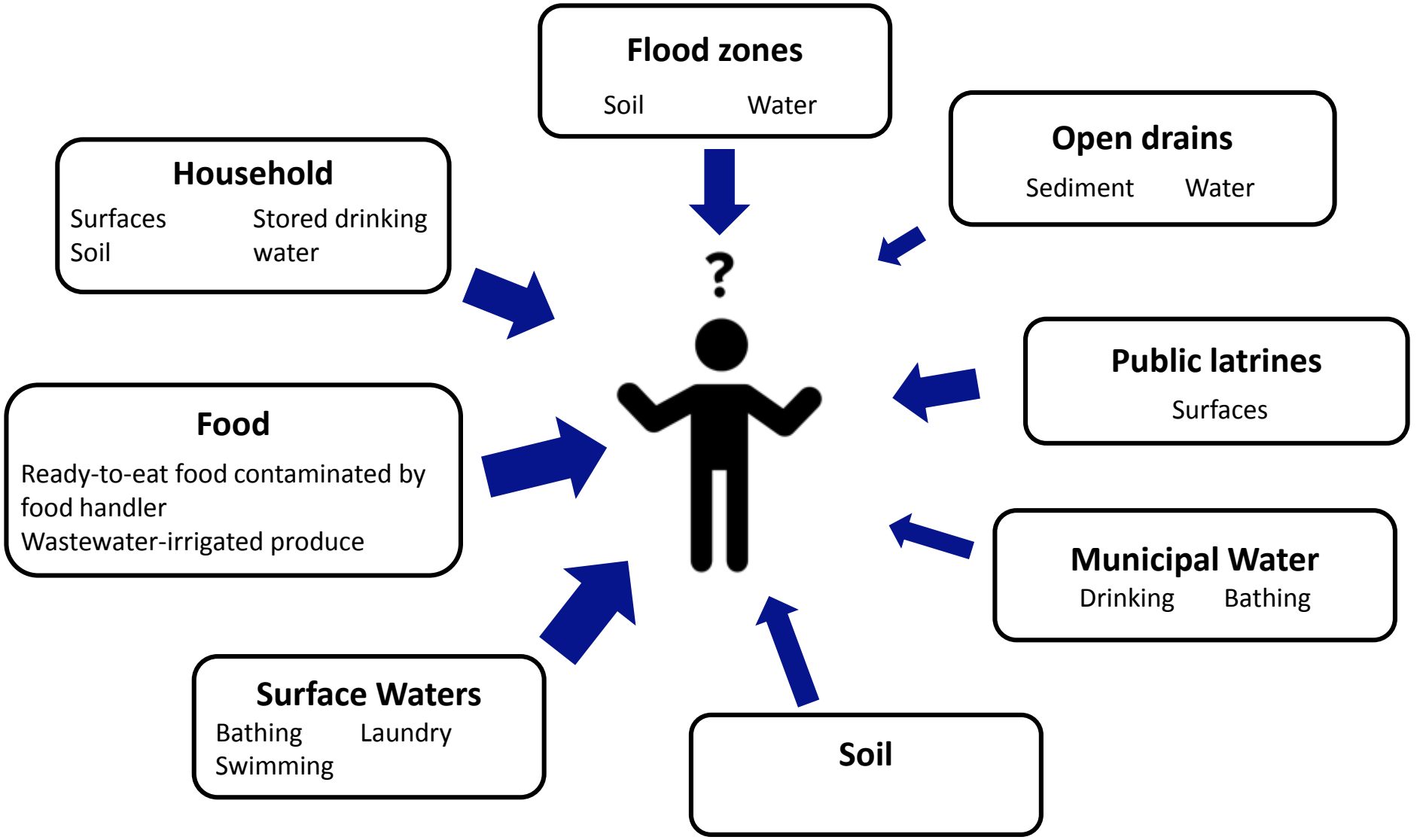
Drinking water

Bathing water

Wastewater-irrigated produce

Soil

Multiple exposure pathways with different risks
Which pathways pose the greatest risk?



Confused designed by Jessica Look for The Noun Project

SaniPath

The SaniPath Exposure Assessment is designed to assess public health risks related to poor sanitation and to help prioritize interventions and investments based on the exposures that have the greatest public health impact.

What is the risk of exposure to fecal contamination in the urban environment?

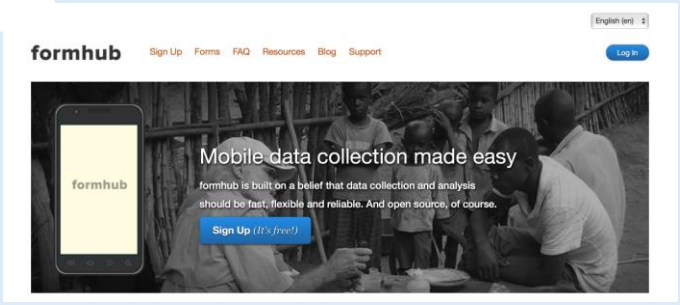
Fecal Contamination + Behavior

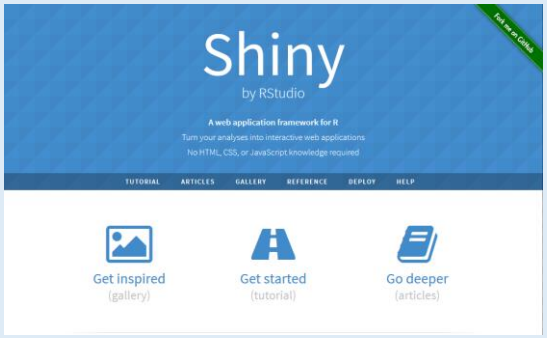
SaniPath Data Collection Methods

- **Behavioral Exposure Data**
  - reported frequency of behavior of adults and children that leads to exposure to fecal contamination
- **Environmental Microbiology Data**
  - Collect environmental samples from relevant exposure pathways
  - Analyze for *E. coli* as a marker for fecal contamination

Overview of SaniPath Tool Architecture

amazon web services™ "The Cloud"





Mobile Data Collection

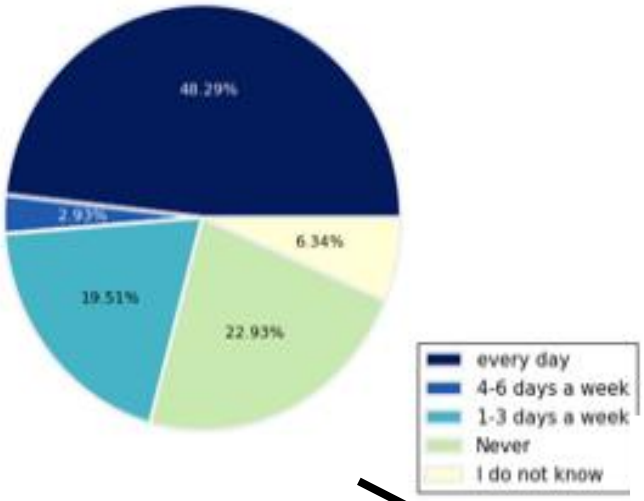
Data/Form Repository

Analysis and Dashboard

SaniPath Approach for Estimating Exposure to Fecal Contamination

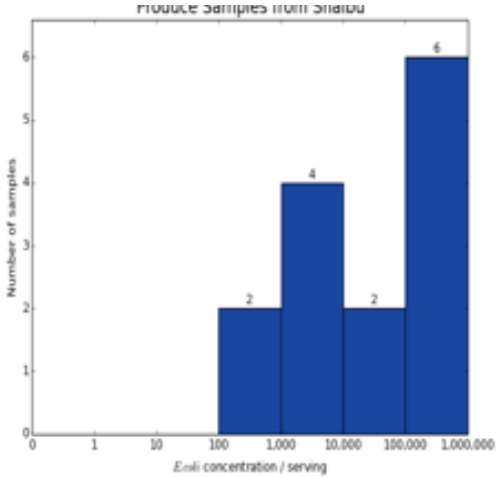
Behavior Frequency

Frequency of produce ingestion in Shiabu (Children)



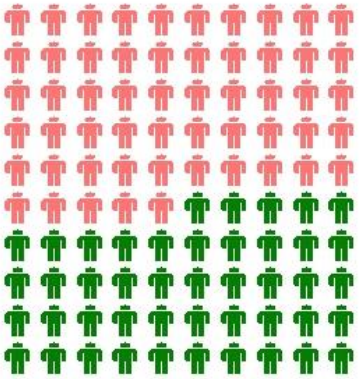
Environmental Contamination

Produce samples from Shiabu



Other parameters: intake volumes, duration of exposure, etc.

Produce (Children)
Percent Exposed = 55%
Log10 Dose 5.4

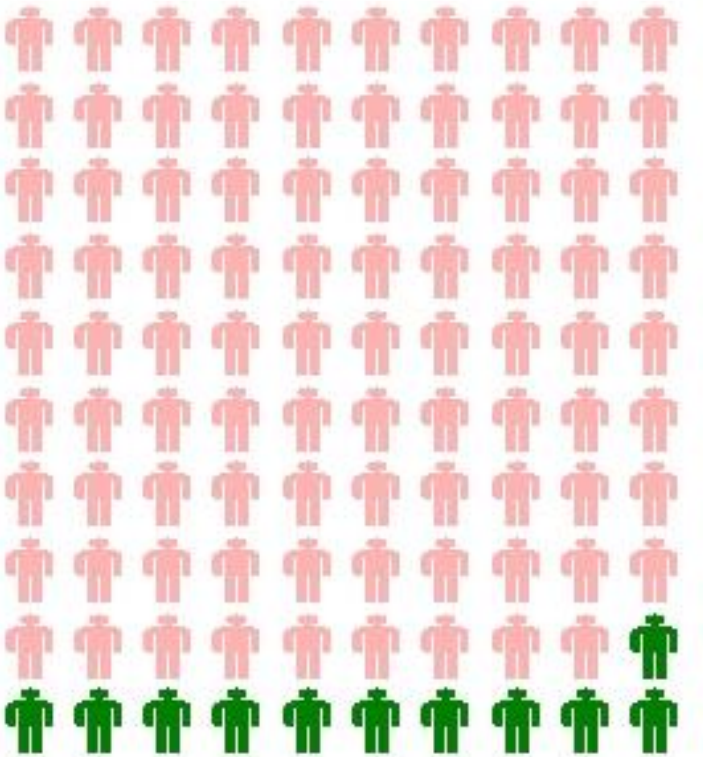


Tool uses Bayesian analysis to estimate the distribution of environmental contamination and frequency of exposure.

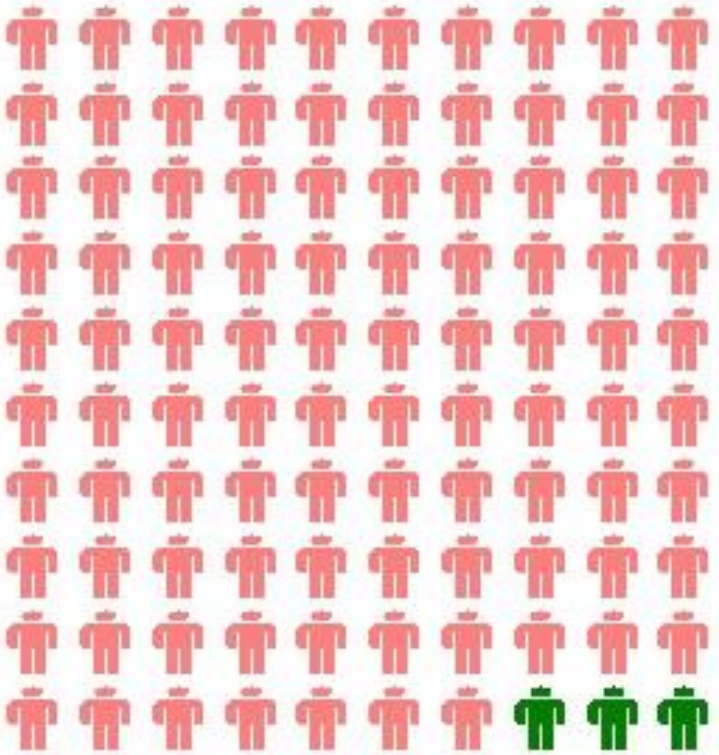
The mean dose and proportion of the population exposed are summarized from simulated distributions and displayed in risk profiles

SaniPath Risk Profiles

Neighborhood in Accra, Ghana
Drinking Water (Adult)
Percent Exposed = 89%
Log10 Dose 3.1



Neighborhood in Vellore, India
Drinking Water (Adult)
Percent Exposed = 97%
Log10 Dose 5.0



Risk profiles show % of population exposed per month (in red) and the average dose of fecal contamination ingested per month (darker red = higher dose).

SaniPath tool deployments: 2012-2016 Primary data collection completed for 17 different neighborhoods

- **Accra, Ghana – 4 neighborhoods**
- **Vellore, India – 2 neighborhoods**
- **Maputo, Mozambique – 2 neighborhoods**
- **Accra, Ghana – 5 neighborhoods**
- **Siem Reap, Cambodia – 5 neighborhoods**
- Atlanta, US – 1 neighborhood, in progress
- Dhaka, Bangladesh – 10 neighborhoods, in progress
- Dakar, Senegal – in progress

Information needs for advocacy and investment decisions

- What is the frequency and magnitude of exposure to fecal contamination in the urban environment?
- Which exposure pathways pose the greatest risk?
  - How do fecal exposure pathways vary in a single neighborhood?
  - How do fecal exposure pathways vary across multiple neighborhoods in the same city?
  - How do fecal exposure pathways vary across multiple neighborhoods in different cities?

How do fecal exposure pathways vary in a single neighborhood?

Chorkor neighborhood, Accra, Ghana, 2016

Open Drains

Drain
Percent Exposed = 72 %
Log10 Dose= 7.07

Produce

Produce
Percent Exposed = 92 %
Log10 Dose= 7

Municipal Tap Water

Piped Water
Percent Exposed = 67 %
Log10 Dose= 5.17

Public Latrines

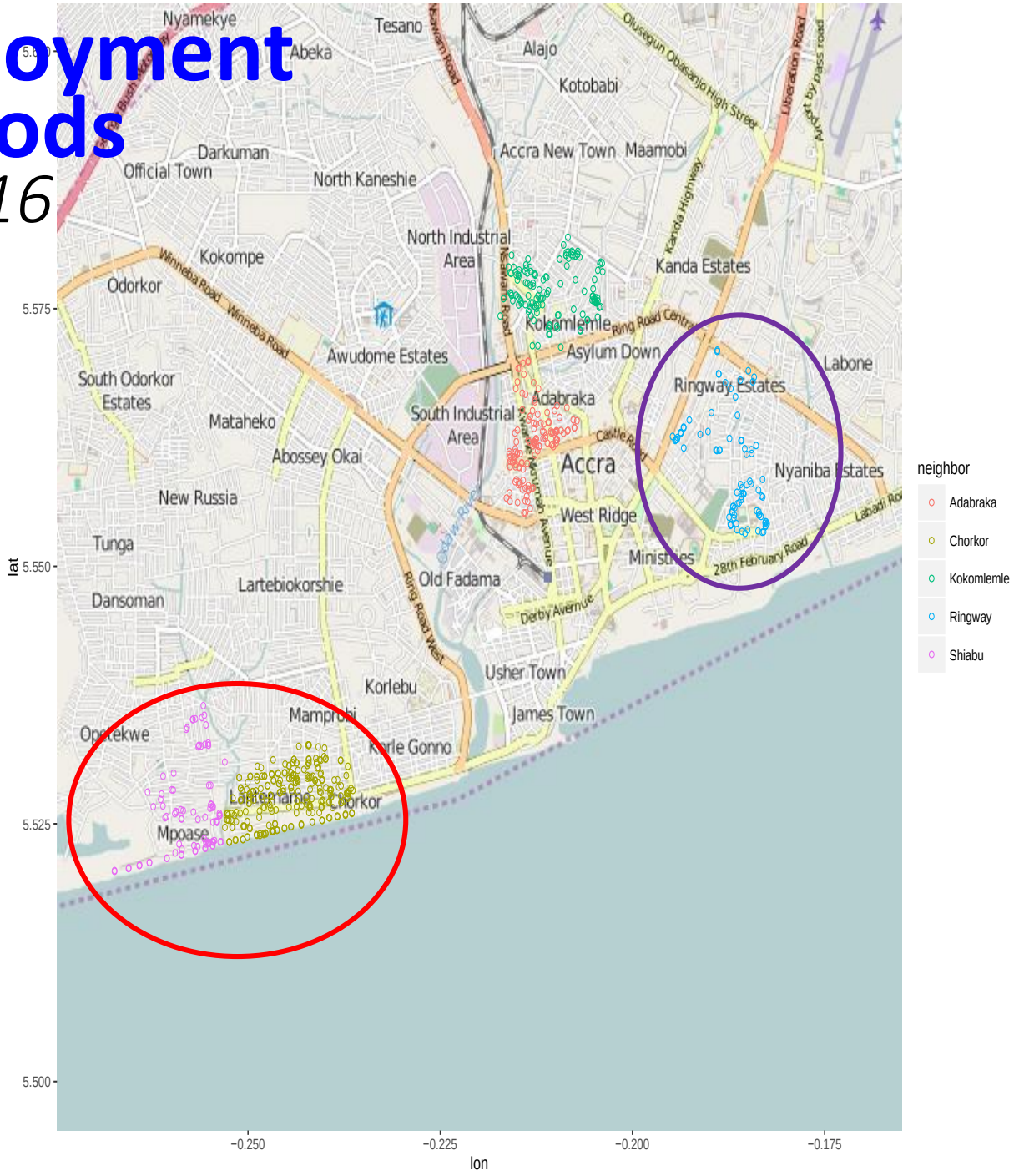
Public Latrine Surface
Percent Exposed = 89 %
Log10 Dose= 1.88

SaniPath Deployment
5 Neighborhoods

Accra, Ghana, 2016

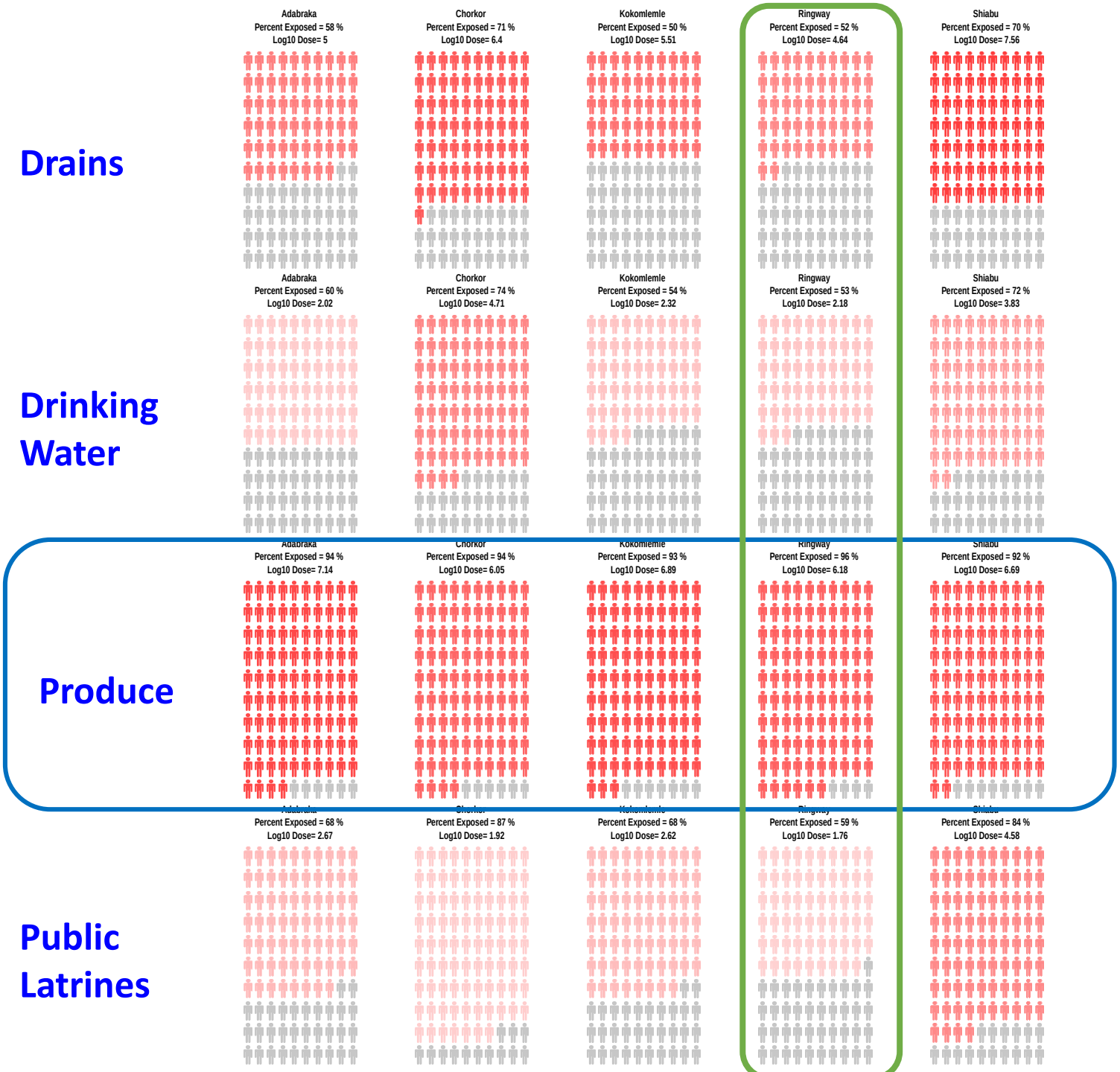
Two adjacent coastal neighborhoods (Shiabu and Chorkor)

Higher income neighborhood (Ringway)



SaniPath Deployment in 5 Neighborhoods

Accra, Ghana, 2016



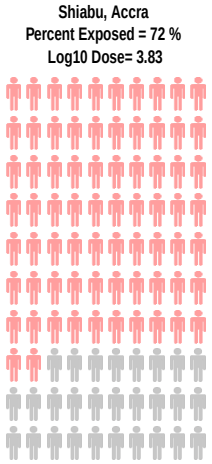
SaniPath Risk Profiles: 3 pathways, 3 cities

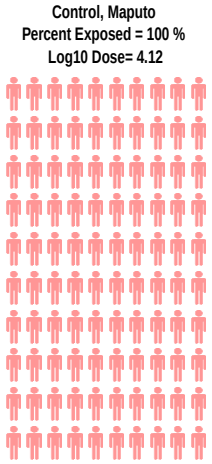
Drains

Greatest variability between 3 cities in magnitude of fecal contamination and exposure was in drain pathway.

Drinking Water

Moderate fecal contamination of drinking water, but high proportion of population exposed





Produce

Produce is always highly contaminated, but proportion of the exposed population varies by city due to cultural differences in diet

SaniPath Value: From Evidence to Action

- Risk profiles show how exposure to fecal contamination **varies across pathways in a single neighborhood**
- Risk profiles show how exposure to fecal contamination **varies across neighborhoods in a single city and across pathways for different cities**
- Municipal authorities can use information on geographic differences and pathway differences to target intervention investments to areas/pathways of greatest risk

How can SaniPath be used to assess risks of environmental transmission of typhoid?

Phase I: Formative Research

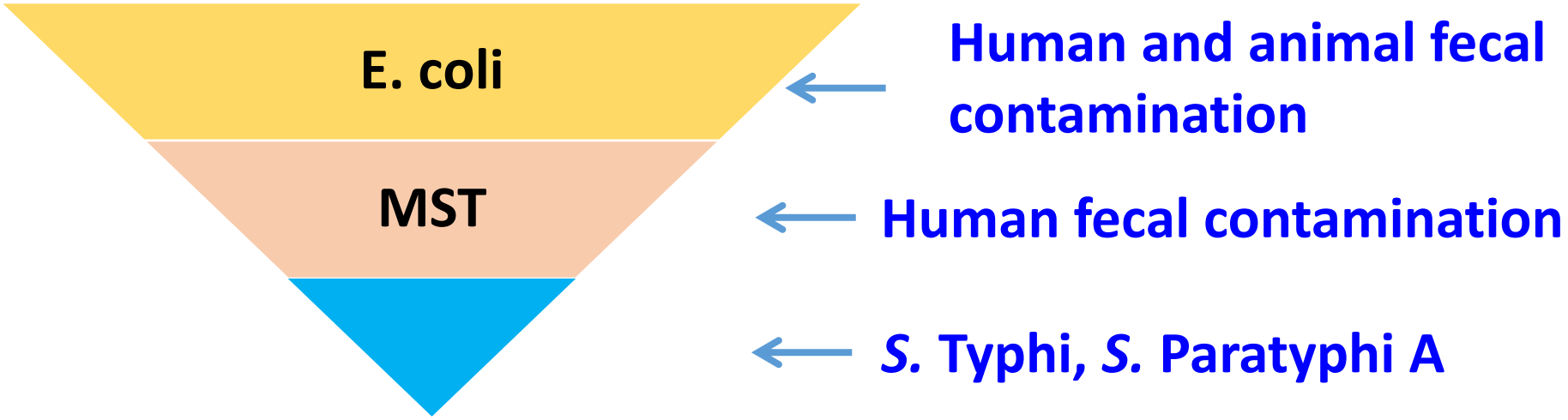
Research Questions

- What vehicles/pathways that transmit *S*. Typhi or *S*. Paratyphi A in outbreaks? In endemic areas?
- What do we know about *S*. Typhi and *S.* Paratyphi A in the environment?
  - Can we detect *S.* Typhi and *S.* Paratyphi A in various environmental samples with good sensitivity and specificity using culture? Using PCR-based methods?
  - What is the decay/persistence of *S.* Typhi and *S*. Paratyphi A in various compartments of the environment?
  - What is the persistence of *S.* Typhi and *S.* Paratyphi A in foods?
- What do we know about exposure behavior of the age groups with peak typhoid incidence? <5 year olds? School age children? Adolescents?

Phase I: Formative Research

Research Questions

- Can we detect **human-specific fecal contamination** in various environmental samples using phage-based microbial source tracking (MST)?



Multiple investigators are collaborating on improved culture-based and molecular methods to detect *S*. Typhi and *S.* Paratyphi A in environmental samples and are sharing methods and protocols.

Phase II: SaniPath-Typhoid exposure assessment in 2 cities

- High incidence city and low incidence city in India
- Conduct structured observations, focus group discussions, GPS tracking of peak typhoid age groups to get more detailed behavior information

  eg. Street food consumption, surface water contact

- Collect relevant environmental samples and test for *E. coli*, phage markers for human feces, and *S*. Typhi and *S*. paratyphi A
- Bayesian modeling to develop city-level risk profiles for typhoid and paratyphoid and identify key transmission pathways

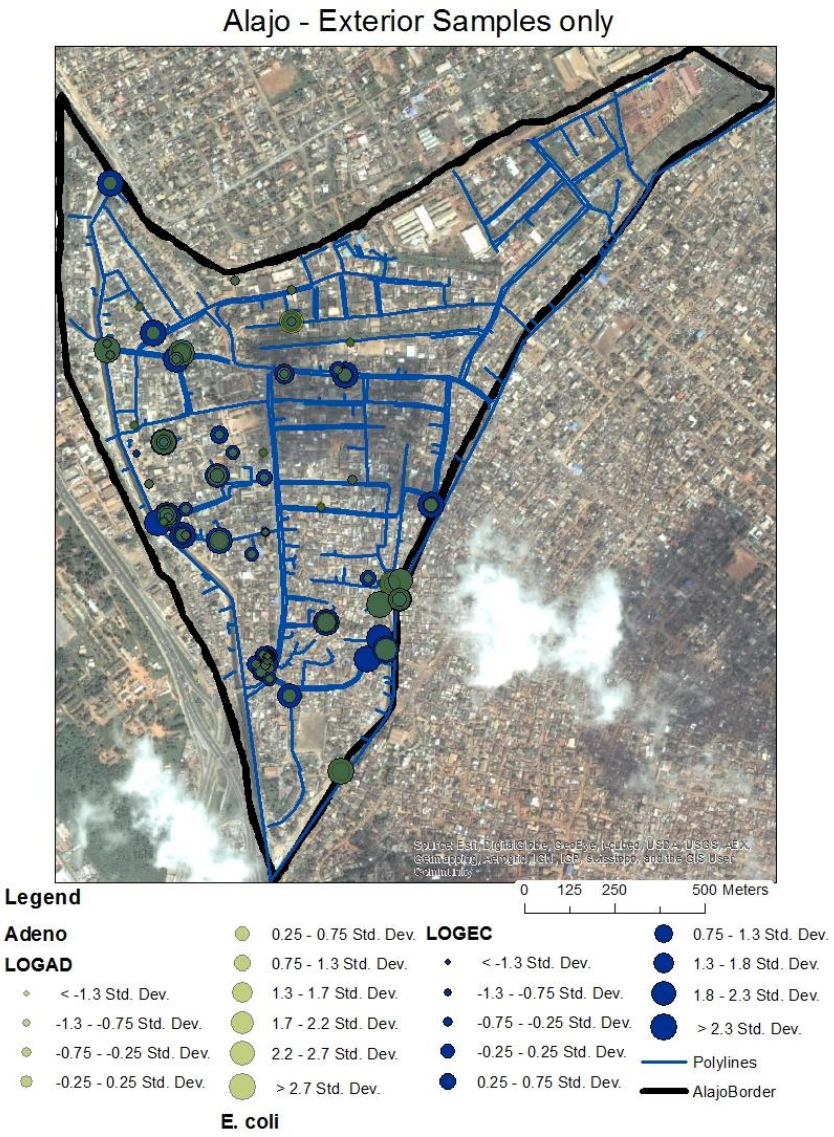
Dhaka, March 2017

Phase III: Develop environmental surveillance strategy for *S.* Typhi and *S.* Paratyphi A

Research questions

- Is there typhoid in the city?
- Where in the city is typhoid found?
- How much typhoid is in the city? Can we estimate typhoid prevalence from environmental surveillance data – eg. Sewage surveillance?

Use spatial analyses to show detection of *S.* Typhi, *S.* Paratyphi A, human-specific phage, and *E. coli* in open drains



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International Expert Committee; Local Expert Committee; SaniPath Advisory Committee

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