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

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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

- WC to sewer
- Leakage
- Not effectively treated
- Effectively treated
- Open defecation
- Safely emptied
- Illegally dumped
- Unsafely emptied
- Left to overflow or abandoned
- Residential environment
- Drainage system
- Receiving waters

98% of fecal sludge stays untreated in environment

2% of fecal sludge is safely managed

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

What are the public health risks from this fecal sludge in the environment?

What information does local government need in order to address this?

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?

Household
- Surfaces
- Soil

- Stored drinking water

Food
- Ready-to-eat food contaminated by food handler
- Wastewater-irrigated produce

Surface Waters
- Bathing
- Laundry
- Swimming

Flood zones
- Soil
- Water

Open drains
- Sediment
- Water

Public latrines
- Surfaces

Municipal Water
- Drinking
- Bathing

Soil

Confused designed by Jessica Look for The Noun Project
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

Mobile Data Collection → Data/Form Repository → Analysis and Dashboard

Amazon Web Services™

“The Cloud”
SaniPath Approach for Estimating Exposure to Fecal Contamination

**Behavior Frequency**

Frequency of produce ingestion in Shiabu (Children)

- 48.29%
- 22.93%
- 19.51%
- 6.34%
- 2.93%

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

**Environmental Contamination**

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

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

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

Produce samples from Shiabu
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?

- **Open Drains**
  - Drain
  - Percent Exposed = 72%
  - Log10 Dose= 7.07

- **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 = 83%
  - Log10 Dose= 1.87
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

Drains

Drinking Water

Produce

Public Latrines
SaniPath Risk Profiles: 3 pathways, 3 cities

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

Drains

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

Drinking Water

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

Produce
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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Thank You

For more information visit SaniPath.org

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