Development and Validation of the SaniPath Rapid Assessment Tool: Characterizing a Complex Problem with a Simple Tool

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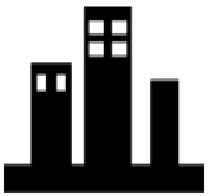
Emory University | Center for Global Safe Water
Bill & Melinda Gates foundation

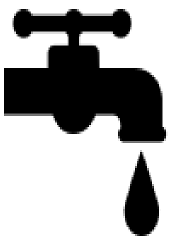
background: urban sanitation

In 2008, for the first time in history, the number of people living in cities **outnumbered** the population in rural areas



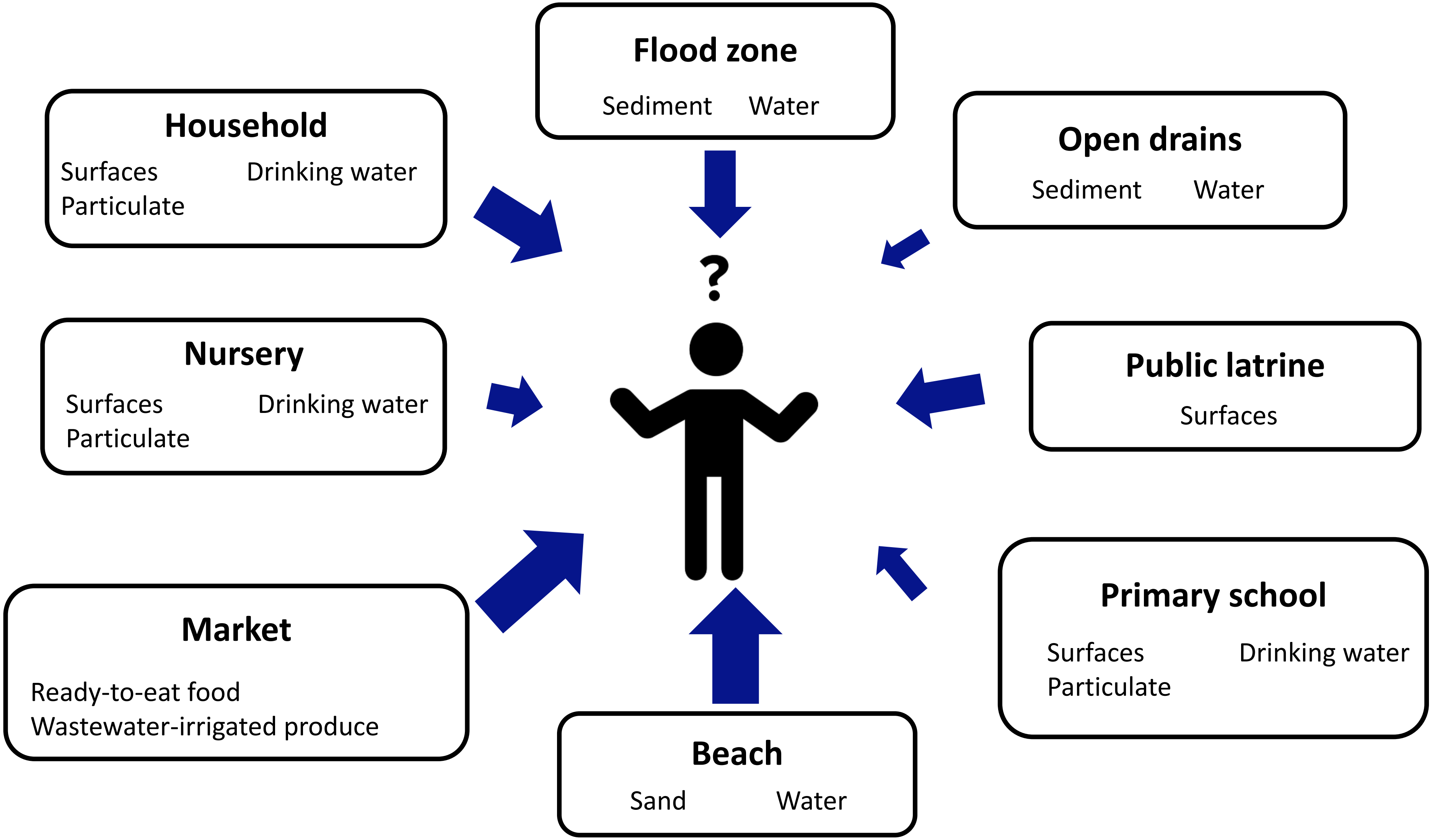
By 2050 the United Nations projects that 65% of global population will live in cities

Rapid growth outpaced ability of government to provide basic services



Crowded Population → Blurring Spaces → Communal Exposure → Disease Transmission

background: how should policy makers prioritize sanitation investments?



Confused designed by Jessica Look for The Noun Project

key goals of rapid assessment tool

Guide users through the collection of relevant data to inform their understanding of risk of exposure

Provide users with easy to use software interface for data entry that can be customized for different contexts

Generate data on relative exposure to fecal contamination in low-income, urban neighborhoods

Synthesize these data to guide community, government, and service providers in their decision-making process

background: in-depth study in Accra, Ghana (phase 1)

We examined a wide range of exposures in both public and private domains and via common vehicles during different seasons in four low-income urban neighborhoods.

PATHWAYS

Marine and Surface Waters, sand, Drinking water- piped water, sachet, stored HH water, Open drains and flooding, Urban agriculture (wastewater irrigation), Primary schools and nurseries, Public latrines, Households

Human Behavior

↓

Key Informant Interviews

Focus Group Discussions

Household Surveys

Structured Observations

↓

800 Household Surveys
500 hrs. Structured Observations

Environmental Fecal Contamination

↓

Environmental Samples

Microbiological Analyses: **pathogens** (norovirus, adenovirus, helminths) and **microbial indicators** (*E. coli*, enterococci, coliphage) of fecal contamination

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Total Environmental Samples: 1855

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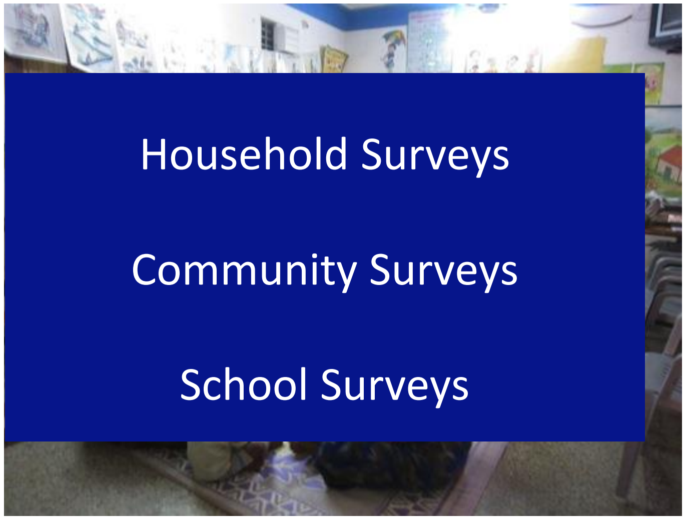
methods: the rapid assessment process

Sarah Abraham, Martha Ormiston, Gilad Fried, and Juan Pablo Bravo from The Noun Project created the icons interview, neighborhood, water, and computer. Schematic created by Suraja Raj

methods: data collection on water and sanitation behavior, and environmental contamination

behavior



Household Surveys

Community Surveys

School Surveys

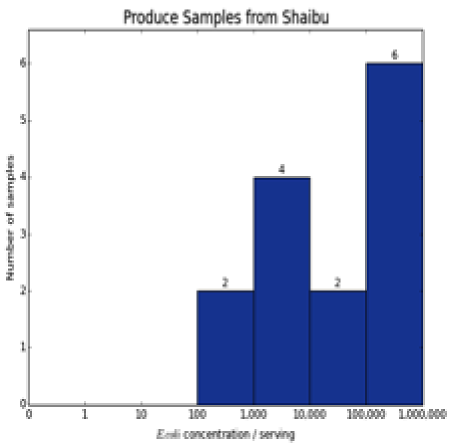
contamination

Membrane Filtration

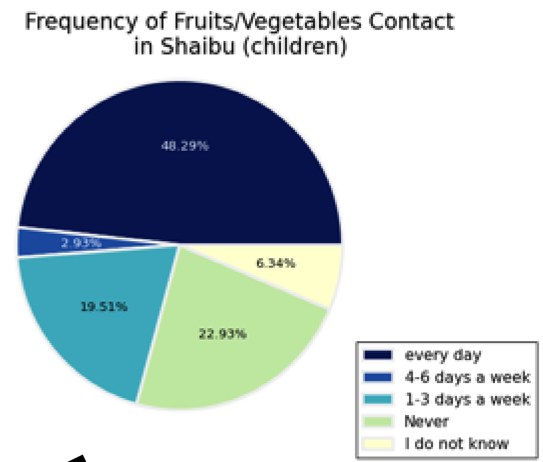
IDEXX Quantitray/2000

methods: environmental and behavioral data are combined to estimate exposure to fecal contamination

Environmental contamination



Behavior Frequency



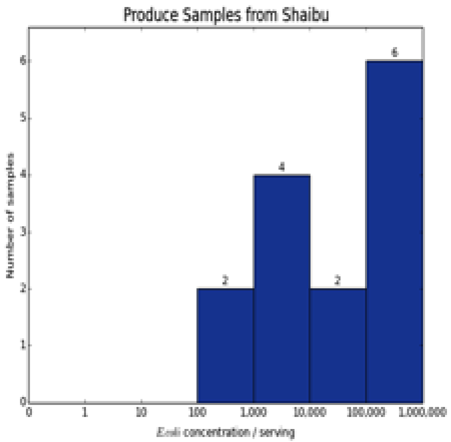
Other parameters*: intake volumes, duration of exposure, etc.

Risk of Exposure

*These values were determined based on a combination of EPA values, literature review and SaniPath Phase 1 data

methods: environmental and behavioral data are combined to estimate exposure to fecal contamination

Environmental contamination



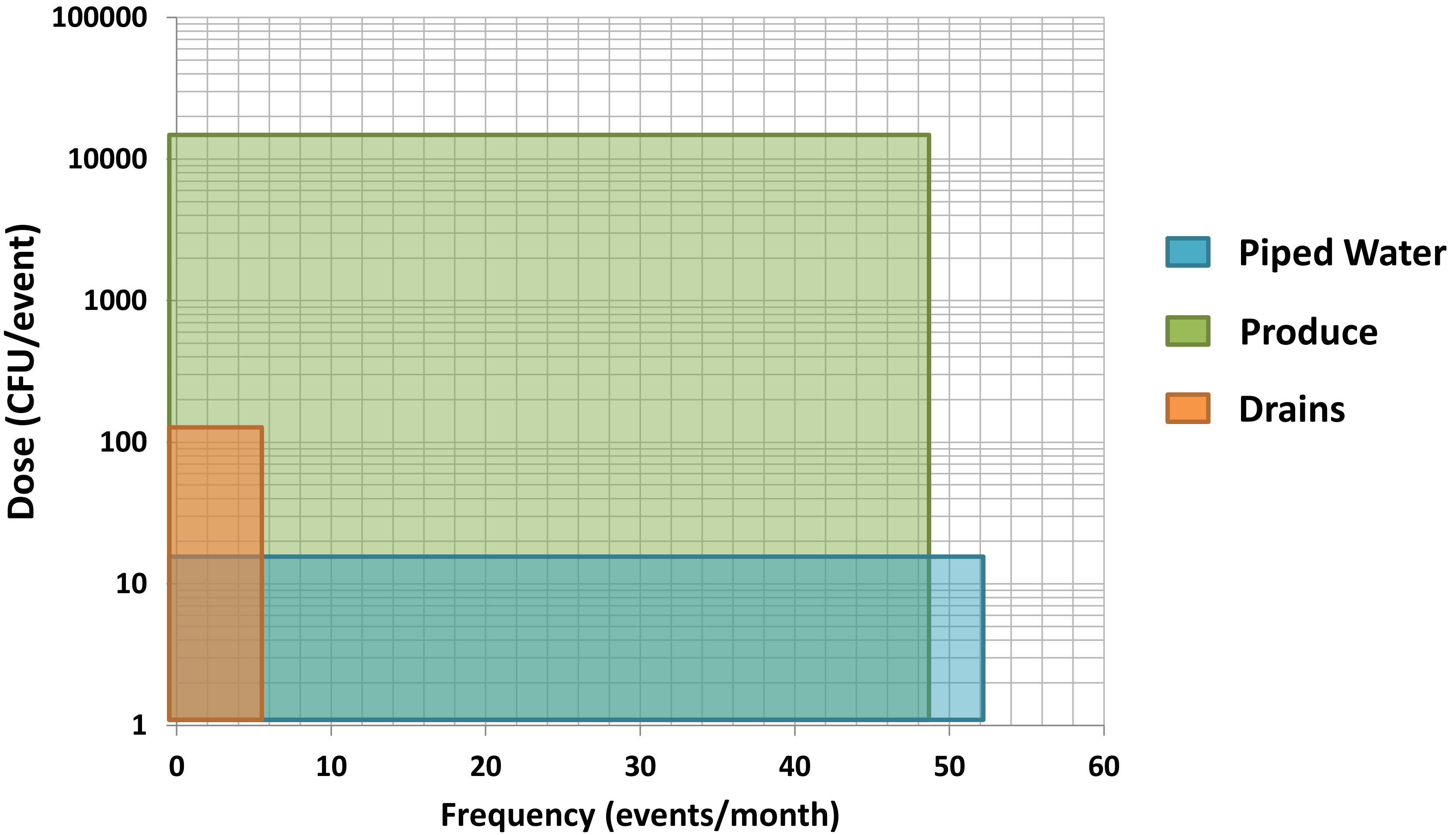
**Other parameters:*
intake volumes,
duration of
exposure, etc.**

average *E. coli* / mL x mL ingested / event = DOSE (CFU *E. coli* ingested / event)

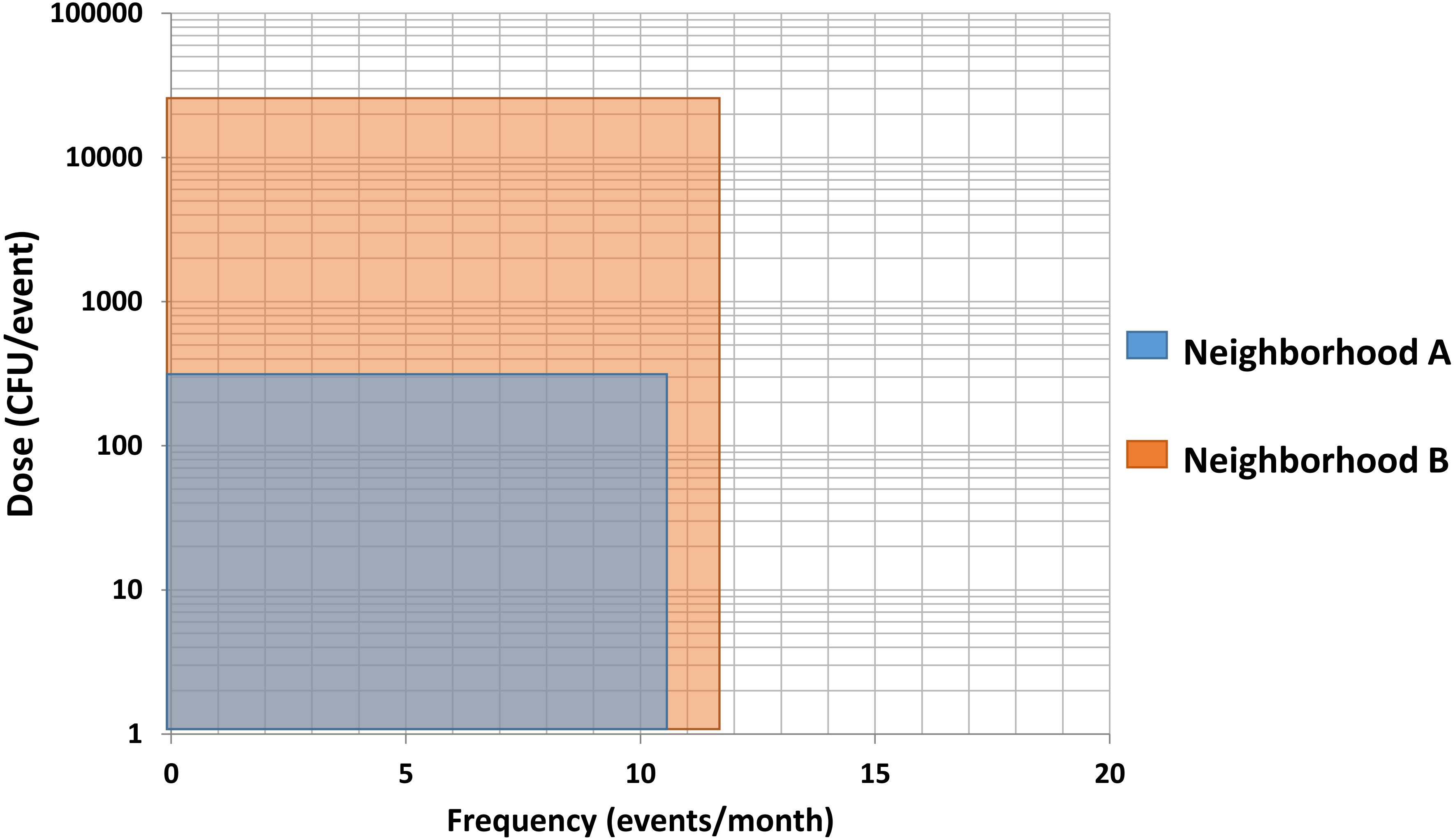
- Oral route only
- Direct ingestion: drinking water, accidental water, and produce
- Indirect ingestion: hand contamination, hand-to-mouth contact behavior

*Volumes were determined based on a combination of EPA values, literature review and SaniPath Phase 1 data

risk of exposure **from three pathways in one neighborhood** for adults



risk of exposure from **piped water** in two neighborhoods

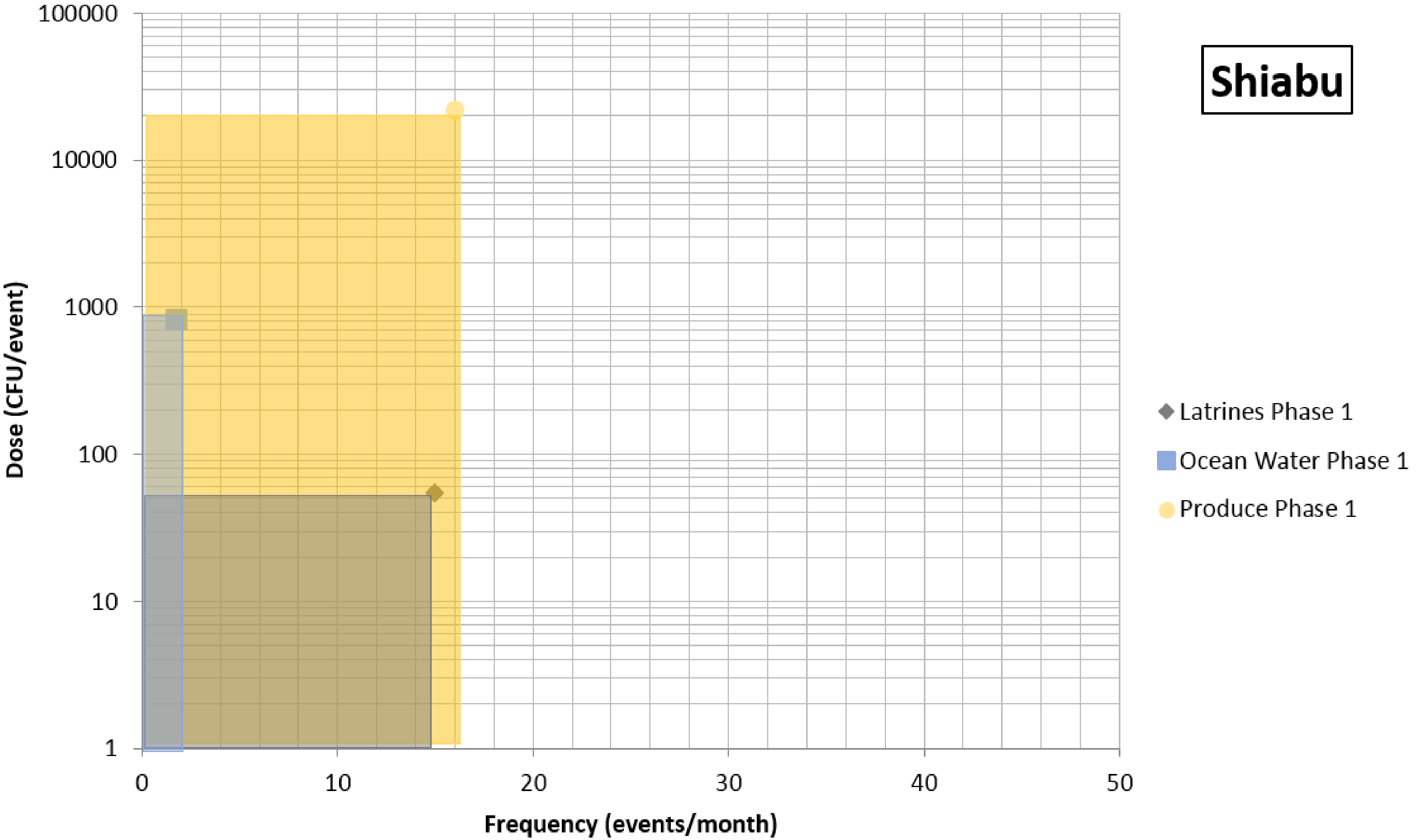


pilot testing in Accra, Ghana

Photo Credit: Suraja Raj

- Piloted tool in same neighborhoods in Ghana as the Phase 1 in-depth study
- Tested the tool for usability & consistency of data collected
- Compare Rapid Tool risk assessment results to results from Phase 1 in Ghana

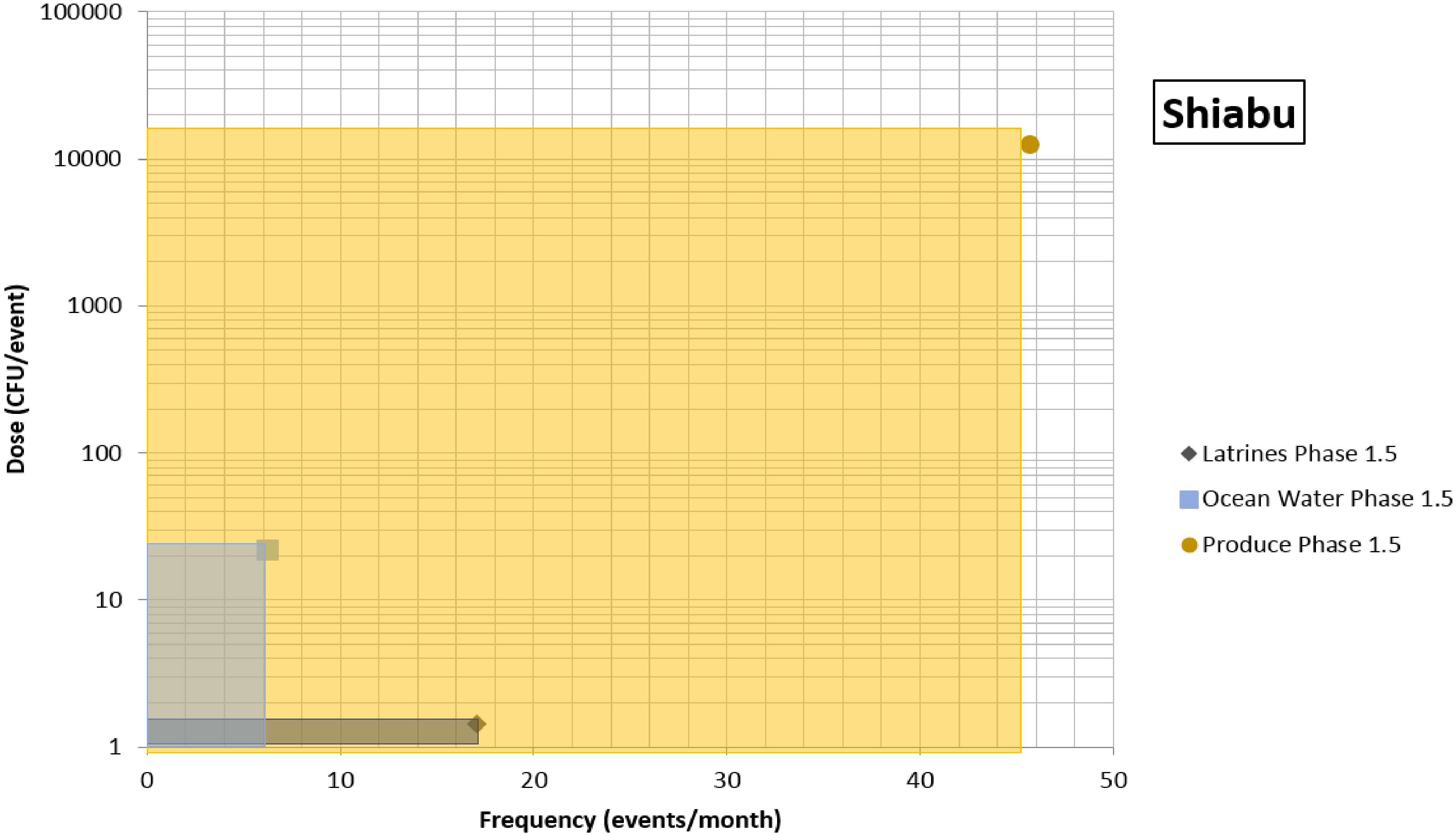
phase 1 vs. rapid tool pilot: phase 1



Highest Risk

Produce

phase 1 vs. rapid tool pilot: rapid tool pilot



Highest Risk

Produce

deployment in Vellore, India

- We tested the Rapid Assessment Tool in two neighborhoods in Vellore, India—a completely different context from Accra. Characteristics of Vellore include:
  - Water scarce area
  - Not coastal
  - Lots of animals
  - Lots of open defecation

- We are collaborating with Christian Medical College, Vellore and the MAL-ED study to validate our environmental risk assessment with health outcome data.
  - Stool samples to look at enteric disease outcomes
  - Matched data collection
  - Link to health outcome data from Mal-ED to provide environmental exposure data

next steps in tool development

Incorporate more sophisticated analysis

Create a centralized database

Develop a mobile application

Add pathways or modules

Pilot tool for pre/post sanitation intervention monitoring

Rapid Assessment Tool Development Team

Bill & Melinda Gates Foundation:

Alyse Schrecongost, Erica Coppel

Center for Global Safe Water, Emory University:

Christine Moe, Clair Null, Peter Teunis, Monique Hennink, Kelly Baker, Amy Kirby, Kate Robb, Habib Yakubu, Heather Reese, Katherine Roguski, Megan Light, Steven Russell, Deema Elchoufi, Andrew Wang

Water Research Institute: Joseph Ampofo

TREND: Nii Wellington

Research Triangle Institute: Matthew Scruggs, Megan Tulloch, Amir Mokhtari, Stephen Beaulieu

Improve International: Susan Davis

Christian Medical College, Vellore: Gagandeep Kang

EMORY UNIVERSITY | Center for Global Safe Water

Thank You

Please visit
www.sanipath.com

Come to Workshop 1A!
Thursday 9:00am-12:30pm

Appendix

one step further…

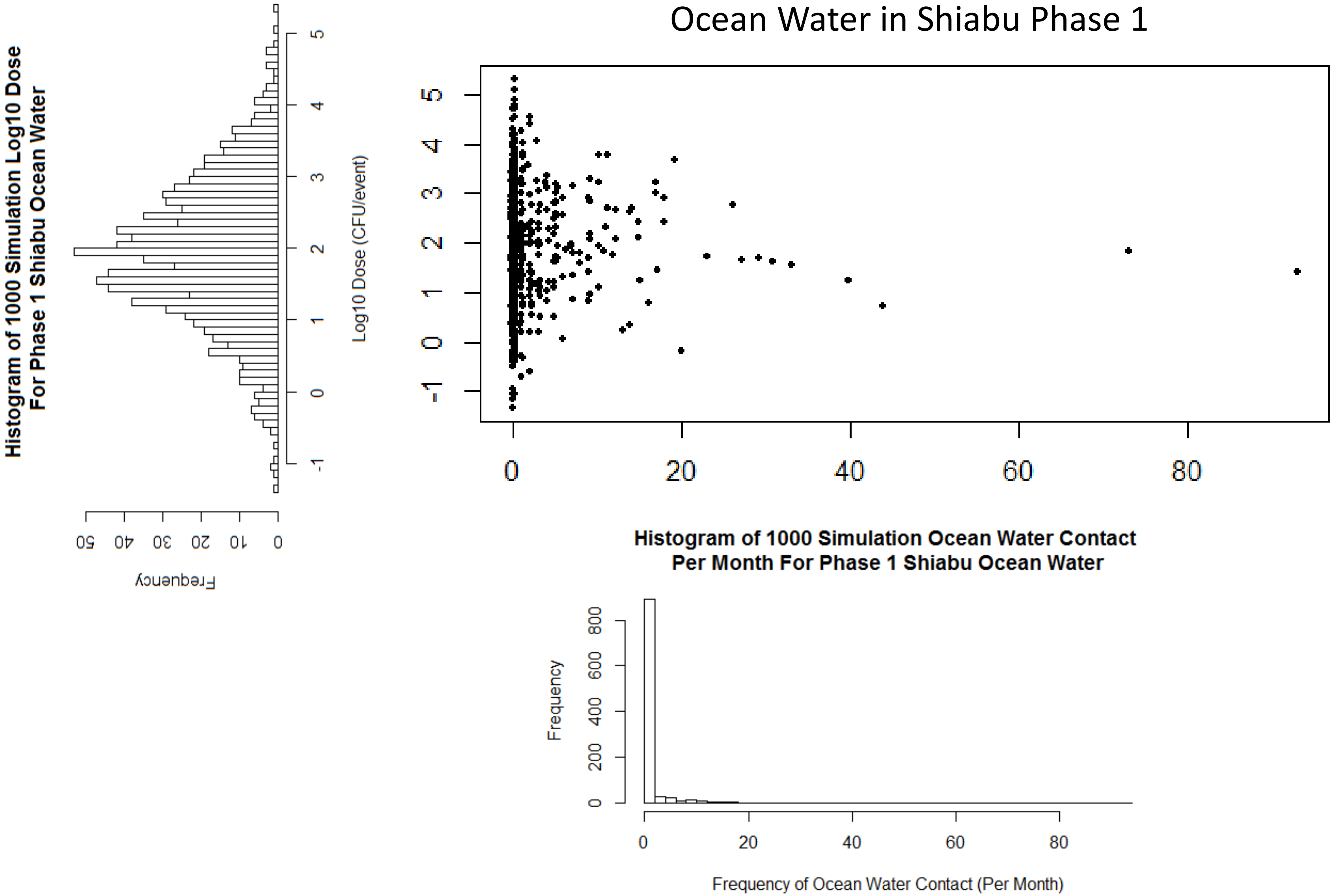
We can estimate the frequency and dose distribution using Bayesian analysis instead of simply using point estimates.

Ocean Water Example:

- A log10 *E. coli* concentration → normal distribution $N(\mu, \sigma^2)$;
- Frequency of ocean water exposure → negative binomial distribution NB(r, p).
- Estimate all parameters by utilizing the data collected and run simulations.

Distribution gives more information about the variance in dose and the percent of people expose to the pathway

Scatter Plot of 1000 Simulation Risk of Ocean Water in Shiabu Phase 1



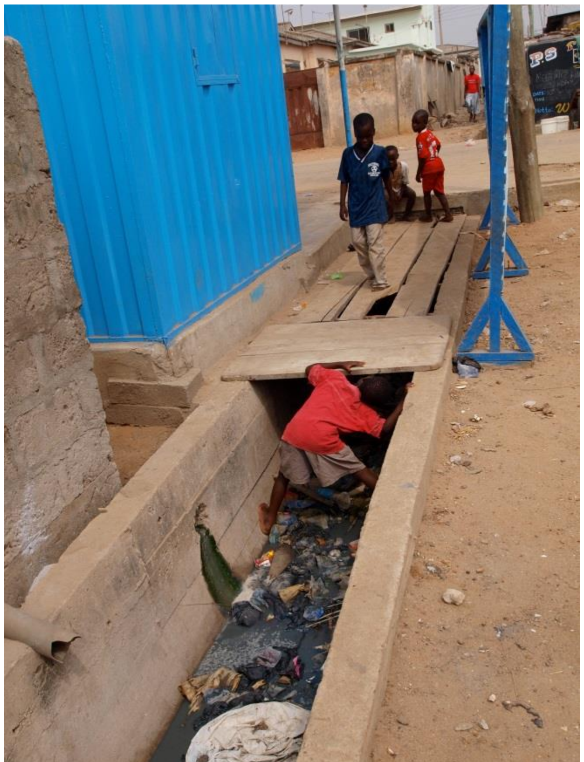
determination of intake values

- The intake value is defined as the volume ingested per exposure event.

- To determine the intake value, we first define the event. We then define the following parameters for children and adults.
  - Exposure Time Unit
    - minutes, days, events
  - Duration of Event
    - in minutes, or not applicable for some exposures
  - Intake Volume
    - in mL

age group

- Given differences in body size and behaviors, separate intake values are calculated for children and adults.



Child entering a drain to retrieve a ball

Woman washing above a drain

We assume that children and adults come into contact with drains differently. For example, a child may intentionally enter a drain and may stay in the drain longer. An adult may incidentally be exposed to drain water while working near a drain.

defining the event

- **Drain Water**
  - Event=entering a drain for any reason (accidental, incidental or intentional)
- **Drinking Water**
  - Event= one day of drinking water from a municipal source

exposure time unit and duration of event

- Exposure Time Unit
  - Some exposures are calculated per day, while others are calculated per event.
    - Drain exposure is calculated in terms of number of drain contact **events per month.**
    - Municipal drinking water exposure is calculated in terms of the number of **days per month** that municipal water is consumed (regardless of the number of times in one day water is consumed).
- Duration of Event
  - For some exposures pathways, like contact with surface water, the duration of event is used in addition to the intake time unit.

Intake Volume and mL ingested/event

- Intake Volume = volume (in mL) that is assumed to be ingested per event
  - Volumes were determined based on a combination of EPA values, literature review and SaniPath Phase 1 data

Exposure Pathway	Age Group	Intake Volume (mL)	Exposure Time Unit	Duration of Event	mL/ Event	Rationale	Assumptions
Drinking Water	Adults	1,043	day	n/a	1043	US EPA value for drinking water consumption per day by adults. Similar averages found in literature review of studies in developing countries.	When participants site how many days per week they drink municipal water, we assume that all of their water consumption on that day is from the municipal source.
	Children	414	day	n/a	414	Same as above but for children	Same as above
Drain Water	Adults	0.06	event	n/a	0.06	Intake volume taken from the US EPA value for an adult wading in water : 3.7ml/hour.	-Any event is likely to lead to high exposure. -There is little or no information about the duration of time adults spend in drains. Therefore, one minute is used to signify 1 drain entry event.
	Children	1	event	n/a	1.0	Inflation of adult US EPA wading value	Same as above with the additional assumption that kids spend more time in drains and have greater contact with drain water.

methods: calculating dose

Intake Value= volume ingested*/exposure event

*Volumes were determined based on a combination of EPA values, literature review and SaniPath Phase 1 data

Exposure Pathway	Age Group	mL/ Event
Drinking Water	Adults	1043
	Children	414
Drain Water	Adults	0.06
	Children	1.0

mL ingested / event x **average *E. coli* / mL** = **dose (CFU *E. coli* ingested / event)**

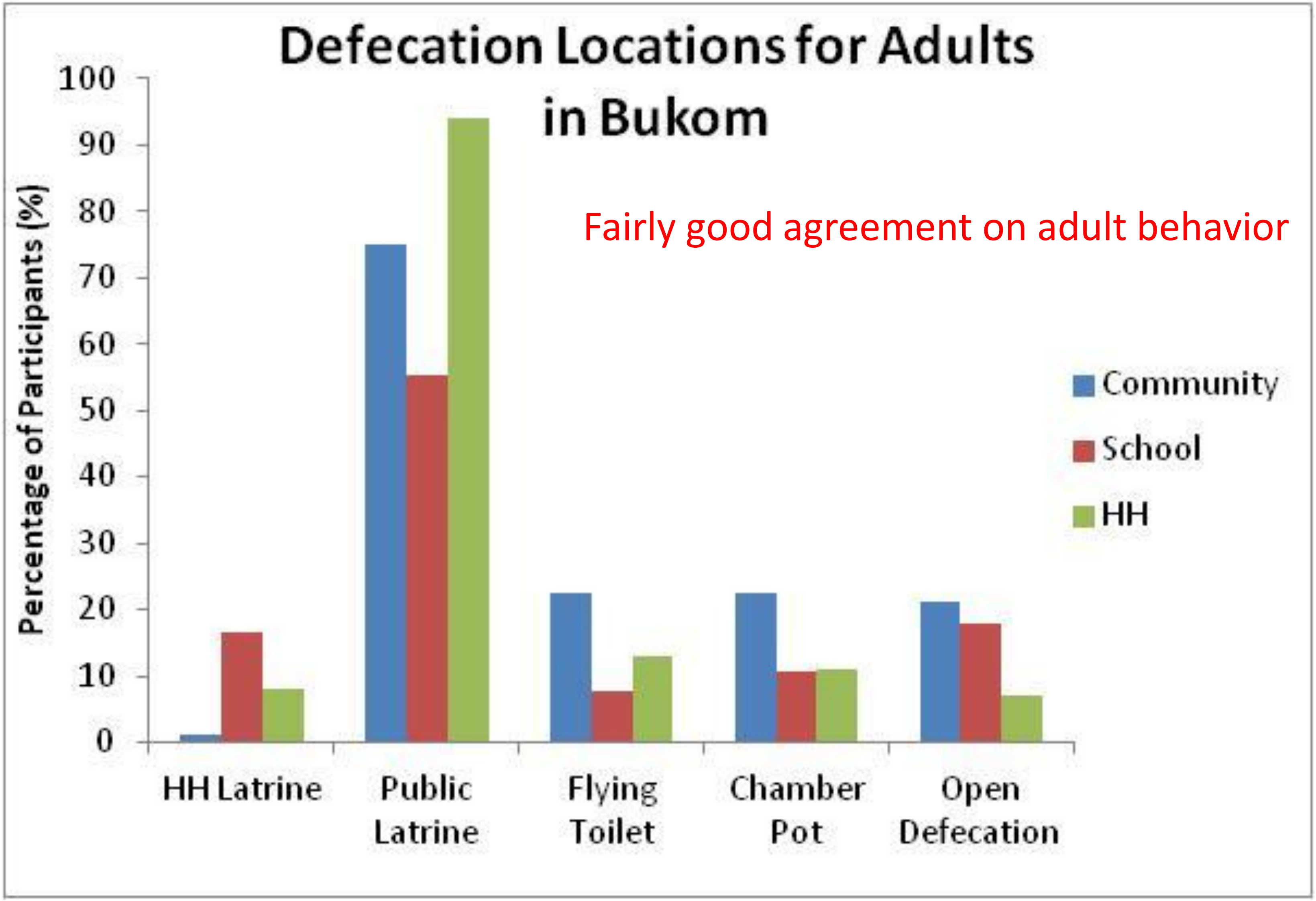
three approaches for collecting information on exposure behavior

- Same basic questions about types of exposure and frequency
  - Community participatory meetings
  - School survey – target 9-12 year old children
  - Household survey
- Different approaches seem to work better in different neighborhoods depending on how well participants know and trust each other.

Adult HH Survey Data, Bukom

Phase 1 (N=199)		**Phase 1.5 (N=100)**	
Categories	**N (%)**	**Categories**	**N (%)**
Beach			
• Daily	16 (8.0)	• > Monthly	15 (15.0)
• 5-10 times / month	6 (3.0)	• Monthly	5 (5.0)
• 1-4 times / month	46 (23.1)	• < Monthly	31 (31.0)
• Never	131 (65.8)	• Never	49 (49.0)
Produce			
• Daily	73 (36.9)	• Daily	31 (31.0)
• Few times / week	77 (38.9)	• Weekly	33 (33.0)
• Weekly	8 (4.0)	• Monthly	24 (24.0)
• Never	39 (19.7)	• Never	12 (12.0)
Public Latrine			
• Daily	130 (65.3)	• > Monthly	89 (89.0)
• Few times / week	51 (25.6)	• Monthly	4 (4.0)
• Weekly	7 (3.5)	• < Monthly	1 (1.0)
• Never	7 (3.5)	• Never	6 (6.0)

Comparing the results from the three approaches to collect information on key behaviors



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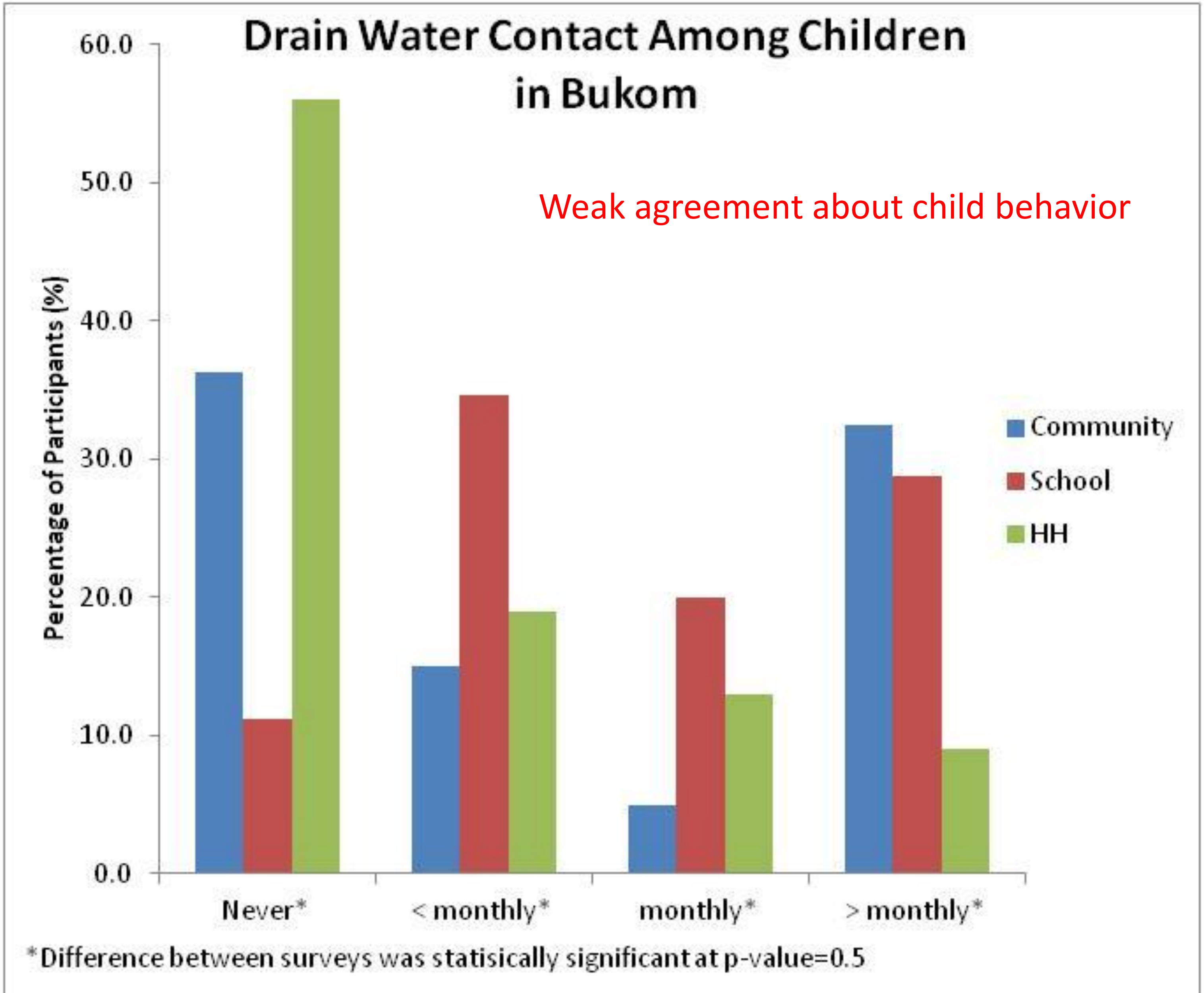
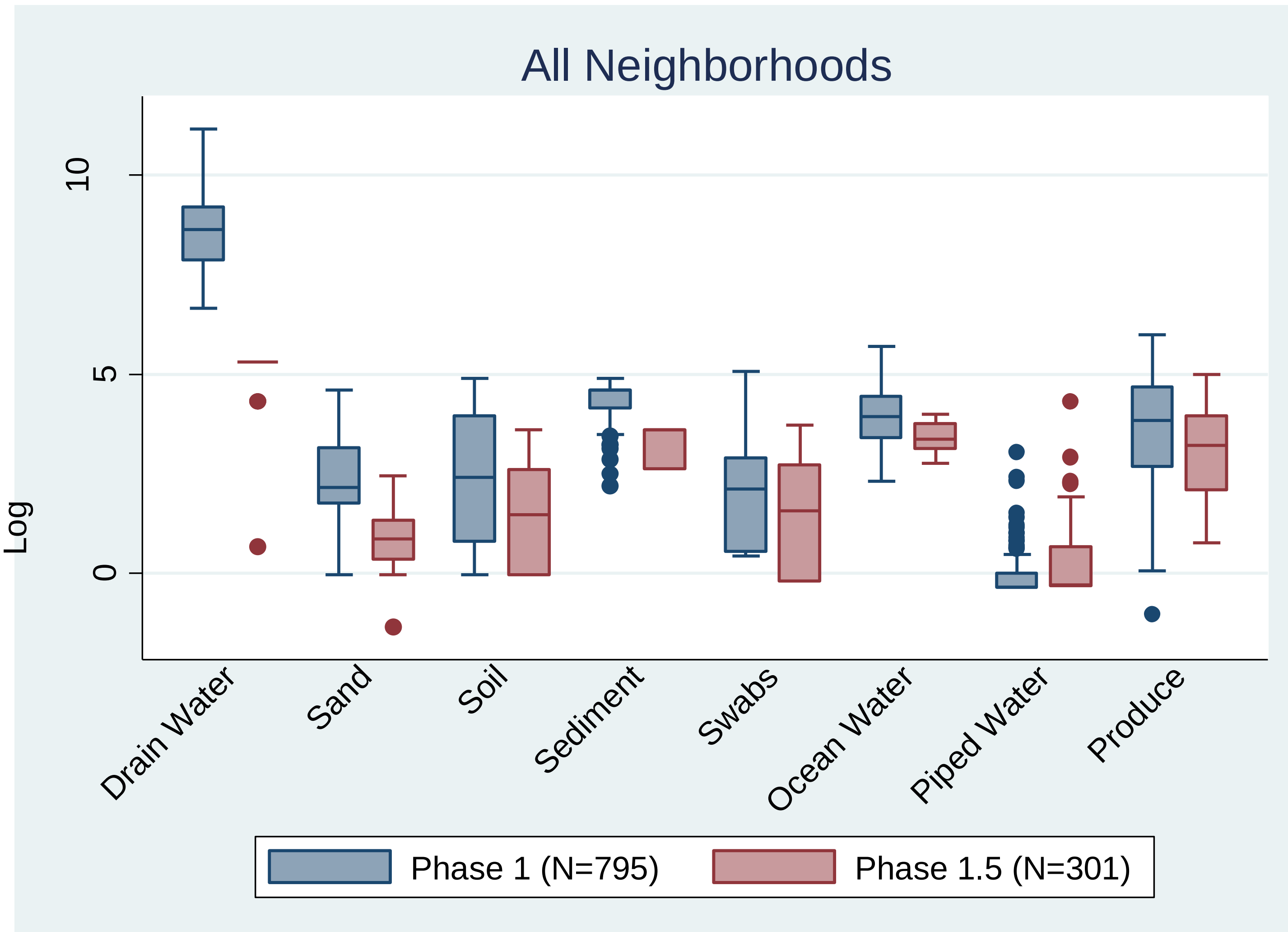
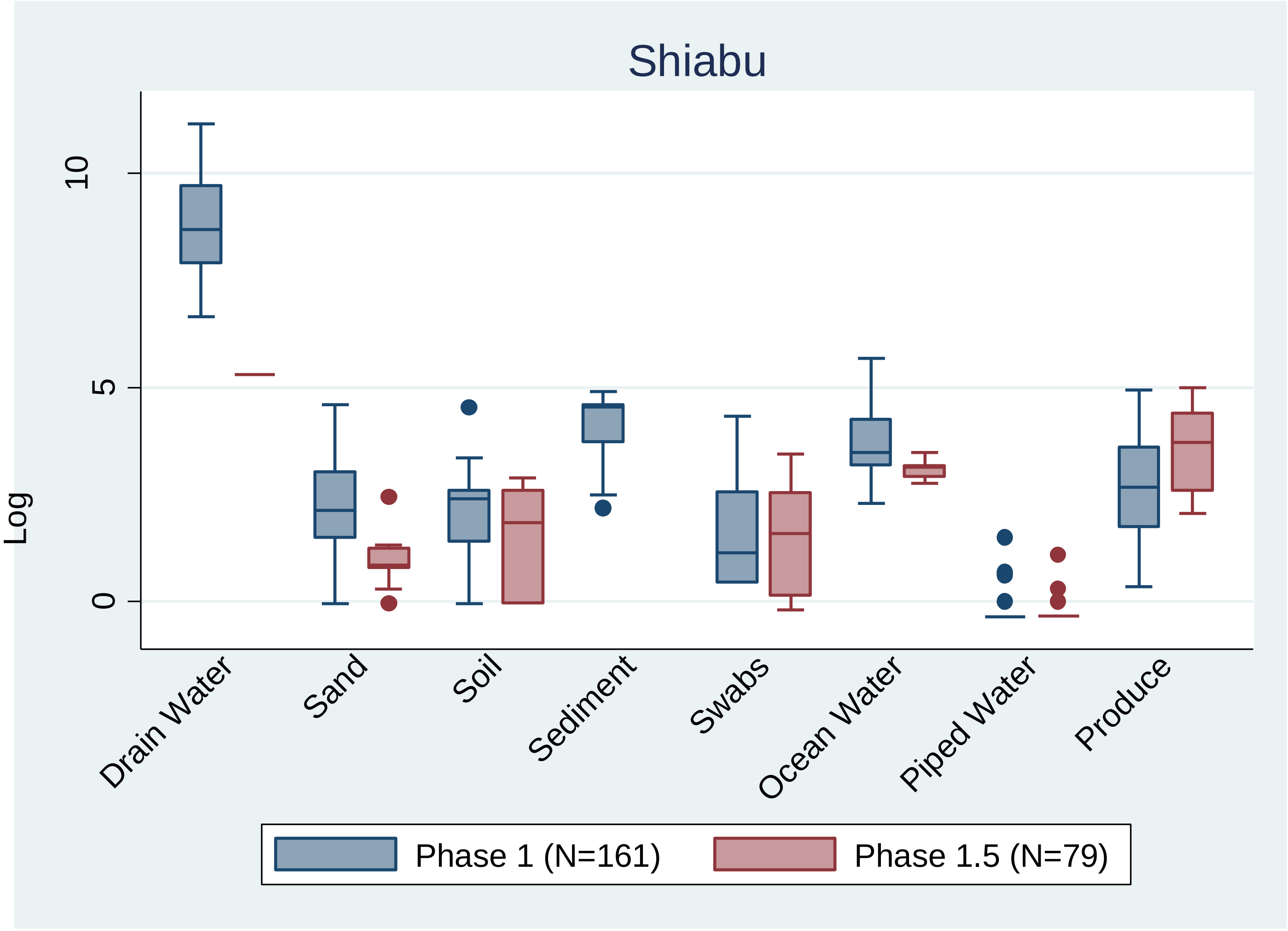


phase 1.5 vs. phase 1 environmental contamination



phase 1.5 vs. phase 1 environmental contamination in Shiabu



phase1.5 risk plots