

# Comparing exposure pathways of enteric pathogens to infants living in low-to-middle-income countries

Leah D. Valentiner (Wellesley College)

Gretchen Guetzlaff (Wartburg College)

Shalimar Vargas Grippo (University of Puerto Rico – Mayagüez)

Mentor: Dr. Daniel K. Sewell Associate Professor

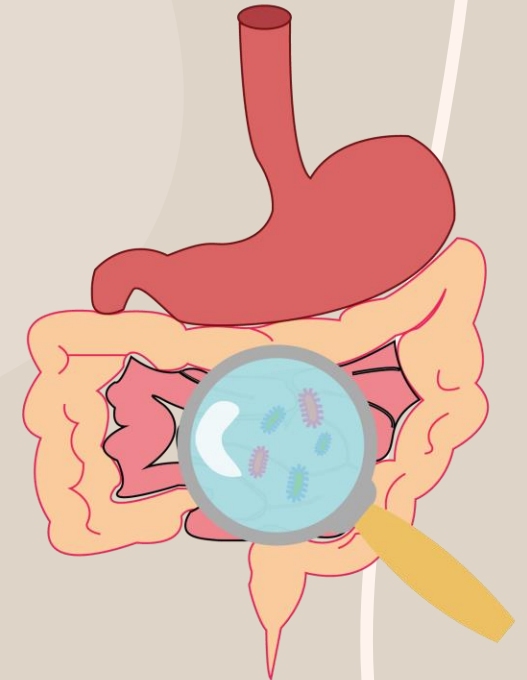
# Objectives

**Our goal: Estimate the rates of behaviors of children that may expose them to pathogens.**

**Broader goal: With the rates found, develop effective intervention strategies for reducing diarrheal diseases in young children in these countries.**

# What is an enteric disease?

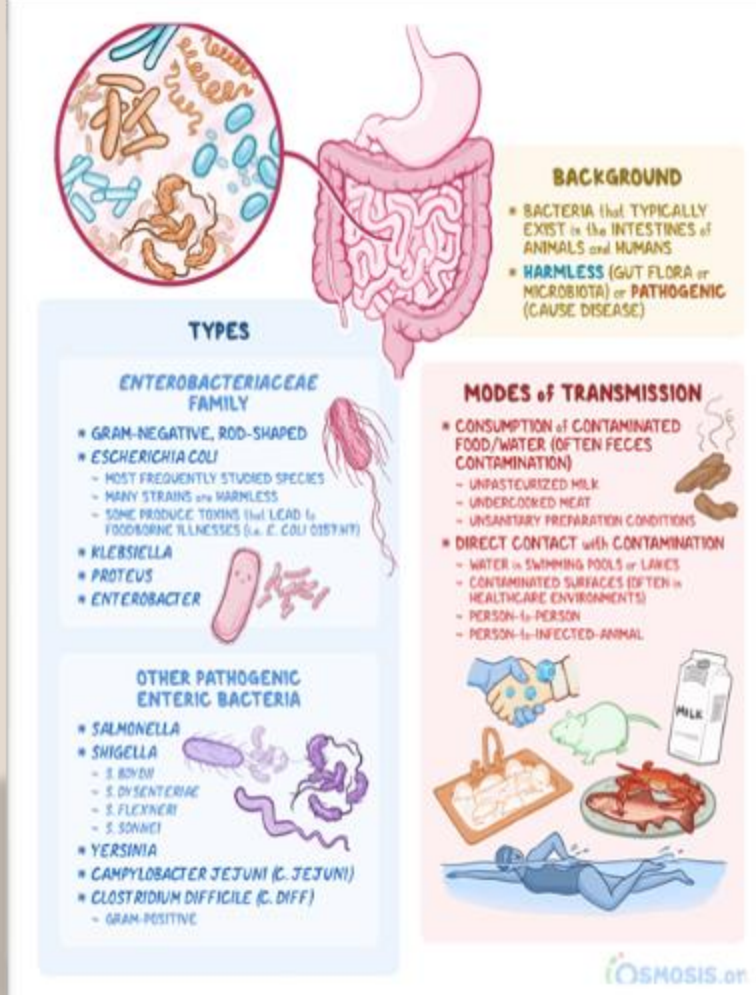
- Group of diseases associated with ingestion of microorganisms and microbial toxins that attack the gastrointestinal track.
- Symptoms:
  - Nausea
  - Vomiting
  - Diarrhea
  - Abdominal cramps
  - Fever
  - Chills with loss of appetite
    - Appear 30 minutes to 10 days after contact



<https://faculty.sites.uci.edu/messaoudilab/gut-microbiome/>

# Enteric Pathogen

- Diarrheal Diseases
  - 750,000 deaths annually
- Bacteria, Viruses, and eukaryotic parasites
- Example:
  - Bacteria: Salmonella, E. coli, Campylobacter, Vibrio
  - Virus: norovirus, rotavirus, and hepatitis A virus.
- Significant concern in areas with poor sanitation



**BACKGROUND**

- BACTERIA that TYPICALLY EXIST in the INTESTINES of ANIMALS and HUMANS
- HARMLESS (GUT FLORA or MICROBIOTA) or PATHOGENIC (CAUSE DISEASE)

**TYPES**

**ENTEROBACTERIACEAE FAMILY**

- GRAM-NEGATIVE, ROD-SHAPED
- **ESCHERICHIA COLI**
  - MOST FREQUENTLY STUDIED SPECIES
  - MANY STRAINS are HARMLESS
  - SOME PRODUCE TOXINS that LEAD to FOODBORNE ILLNESSES (i.e. E. COLI O157H7)
- **KLEBSIELLA**
- **PROTEUS**
- **ENTEROBACTER**

**OTHER PATHOGENIC ENTERIC BACTERIA**

- **SALMONELLA**
- **SHIGELLA**
  - S. BOYDII
  - S. DYSENTERIAE
  - S. FLEXNERI
  - S. SONNEI
- **YERSINIA**
- **CAMPYLOBACTER JEJUNI (C. JEJUNI)**
- **CLOSTRIDIUM DIFFICILE (C. DIFF)**
  - GRAM-POSITIVE

**MODES of TRANSMISSION**

- CONSUMPTION of CONTAMINATED FOOD/WATER (OFTEN FECES CONTAMINATION)
  - UNPASTEURIZED MILK
  - UNDERCOOKED MEAT
  - UNSANITARY PREPARATION CONDITIONS
- DIRECT CONTACT with CONTAMINATION
  - WATER in SWIMMING POOLS or LAKES
  - CONTAMINATED SURFACES (OFTEN in HEALTHCARE ENVIRONMENTS)
  - PERSON-to-PERSON
  - PERSON-to-INFECTED-ANIMAL

*iOSMOSIS.org*

[Enterobacter: Video, Anatomy, Definition & Function | Osmosis](#)

# Data Collection in Jericho

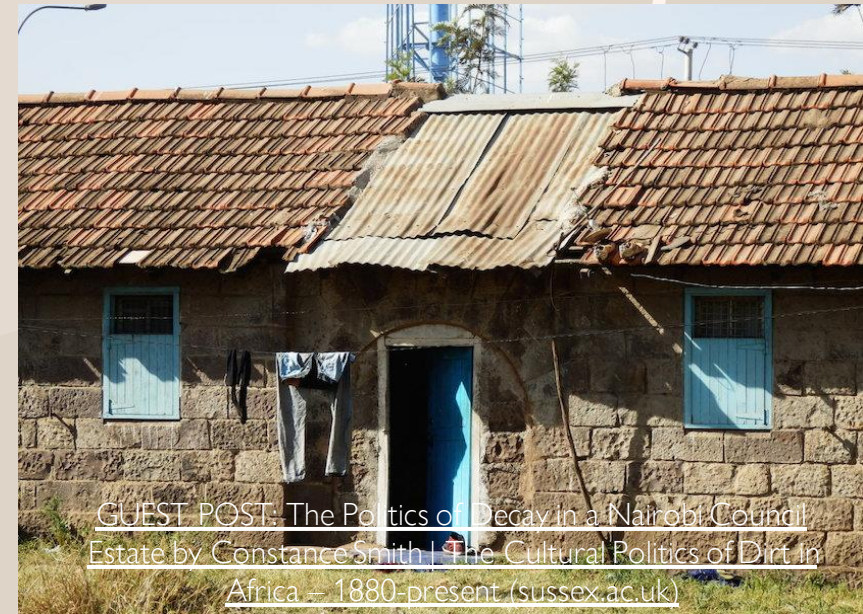
- Lower poverty levels compared to Kibera
- Better access to basic services



[Kaloleni where the mighty once lived | Nation](#)



[Kaloleni: a Kenyan Garden City - INTI - International New Town Institute](#)



[GUEST POST: The Politics of Decay in a Nairobi Council Estate by Constance Smith | The Cultural Politics of Dirt In Africa - 1880-present \(sussex.ac.uk\)](#)

# Data Collection in Kibera

- Extreme Poverty
- Largest slum in Nairobi
- Largest urban slum in Africa



Inside Kibera Slums in Nairobi, Kenya - The Roaming Fork

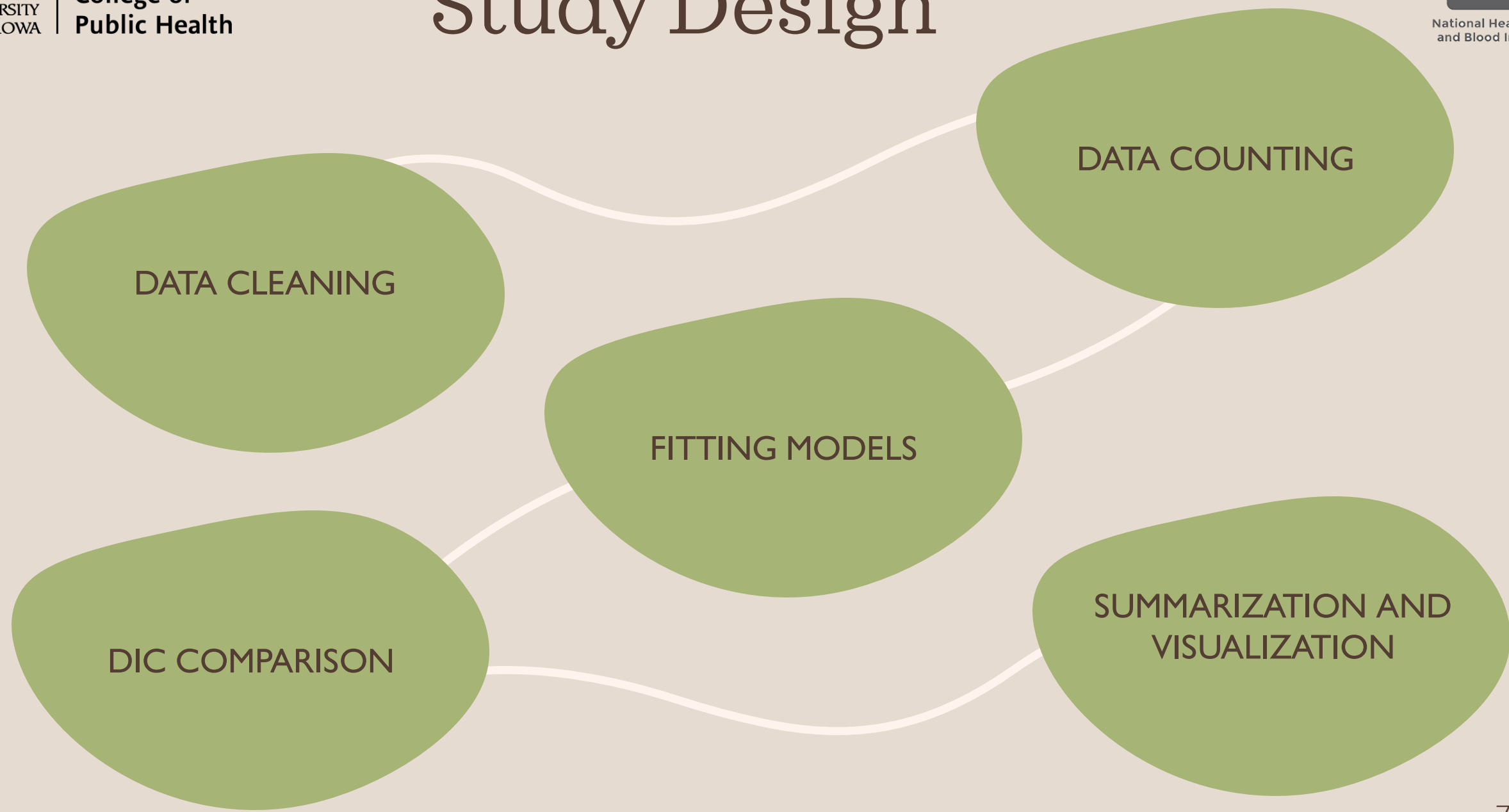


Kibera: Life in Kenya's biggest slum | CNN



Children in kibera slum hi-res stock photography and images - Alamy

# Study Design



# Data Cleaning

- NA removal
- Changing columns
  - Spaces changed to underscores or excluded
  - Combine data for continuity
- Merging original data with data obtained from the counting process (next slide)



# Data Counting

- Some behaviors required counting based on behavior type
- Counting function
  - Behavior of interest (BOI)
  - Separate by subject and day of observation
- One count = BOI + hand in mouth
  - Not counted if hands were washed
- Summed subject counts
  - Run through model fitting function (next slide)

# Fitting Models

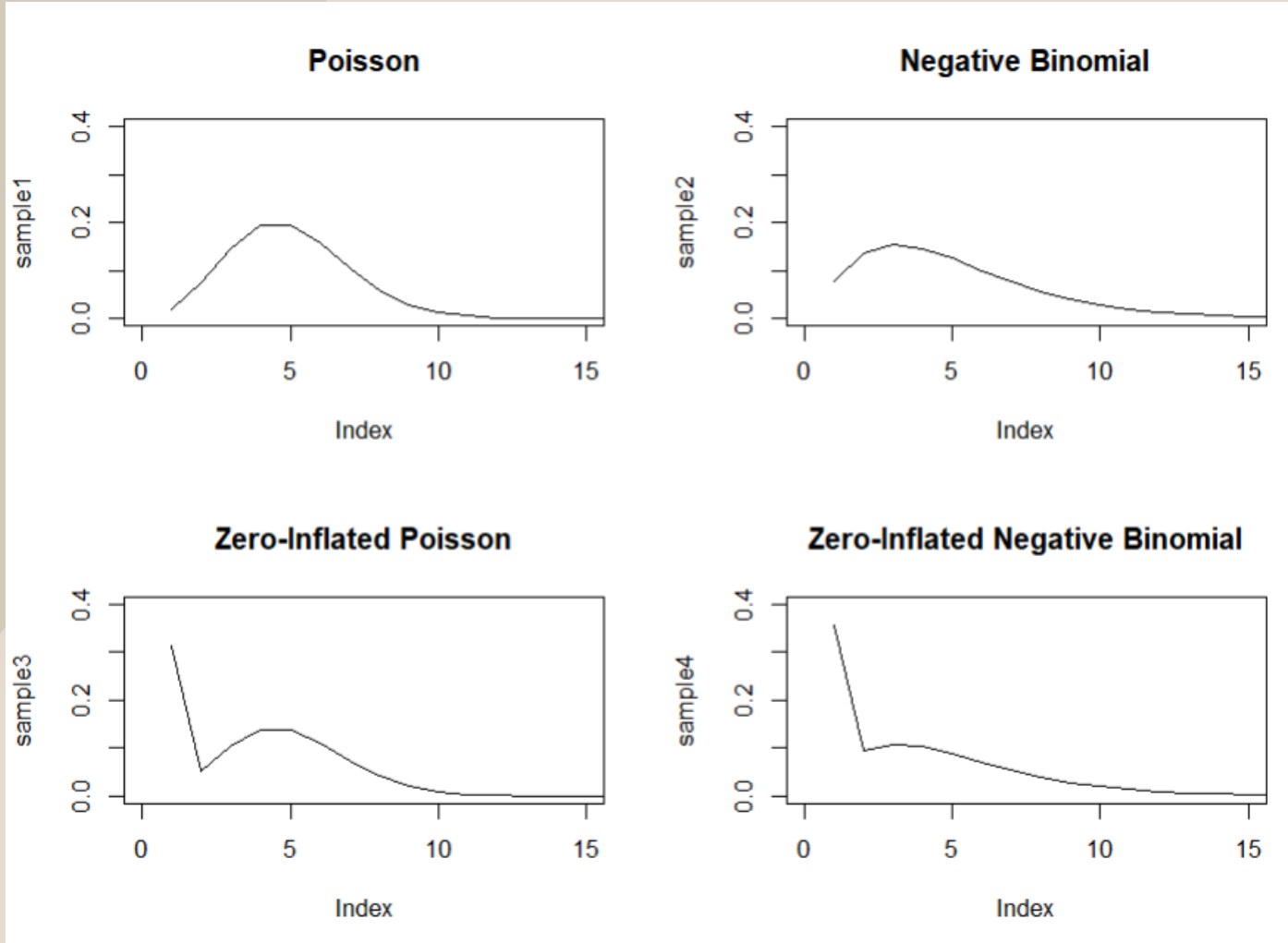
Poisson

Negative Binomial

Zero-Inflated Poisson (ZIP)

Zero-Inflated Negative Binomial (ZINB)

# Fitting Models

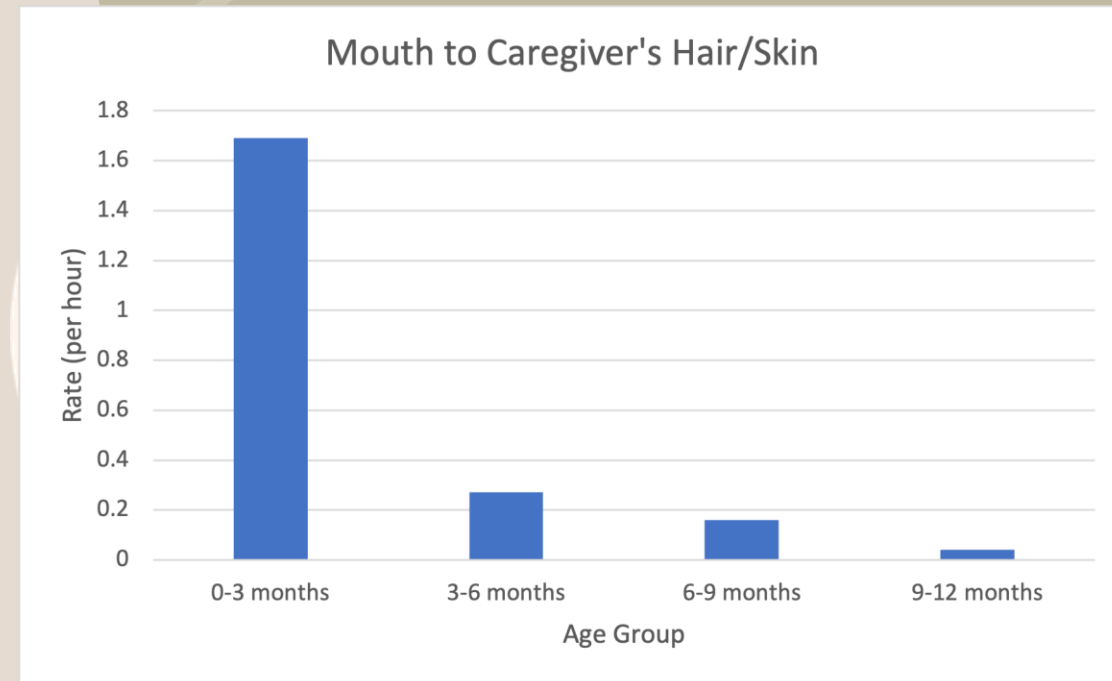


# DIC Comparison

- 4 types of models (previous slide)
- 4 types of categorization:
  - 3-month age bins (0 months to 12 months)
  - Neighborhood (Jericho vs. Kibera)
  - Age and neighborhood
  - No categorization
- Deviance Information Criterion (DIC)
  - Model selection criterion
  - Bayesian stats
  - Want lowest DIC

# Results/Analysis

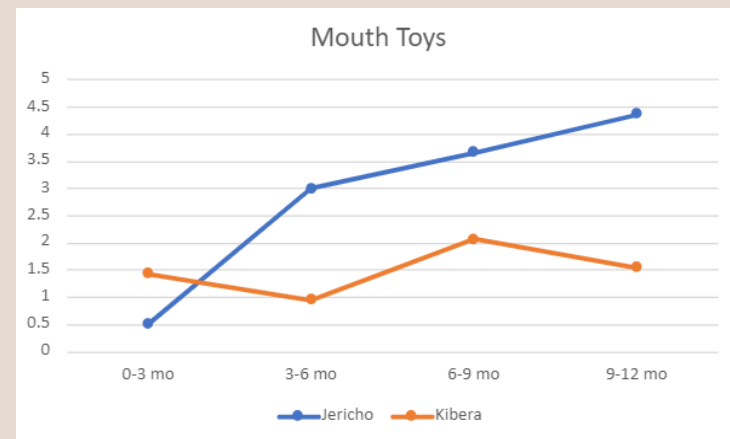
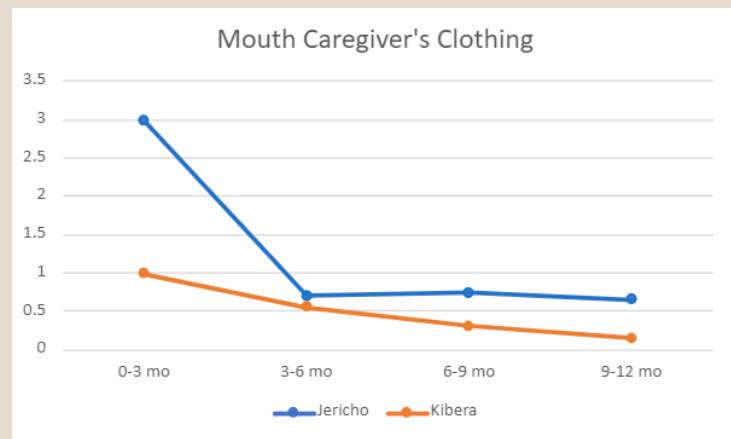
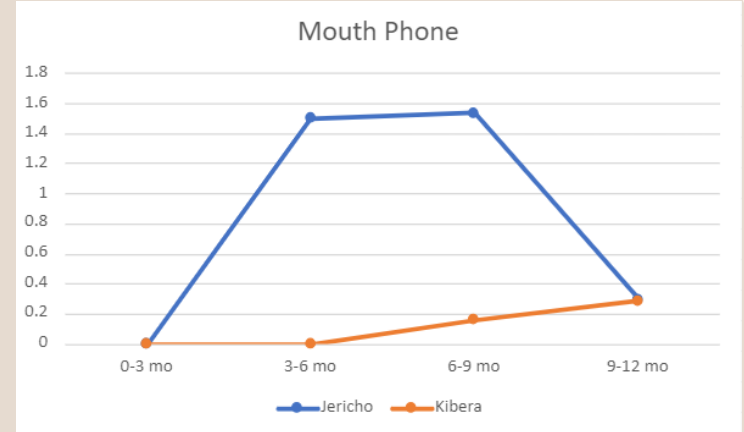
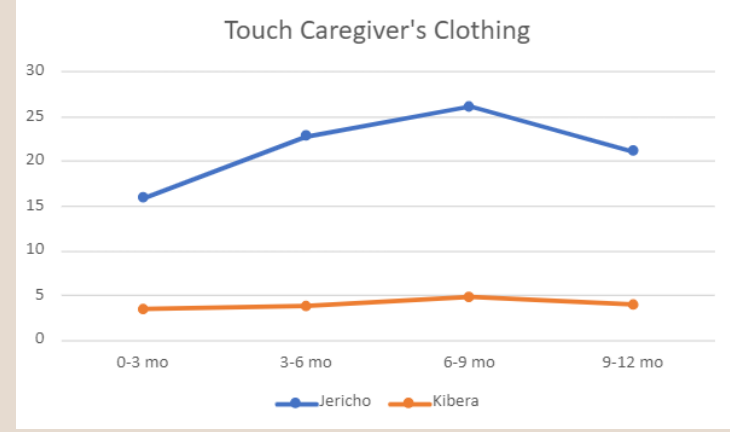
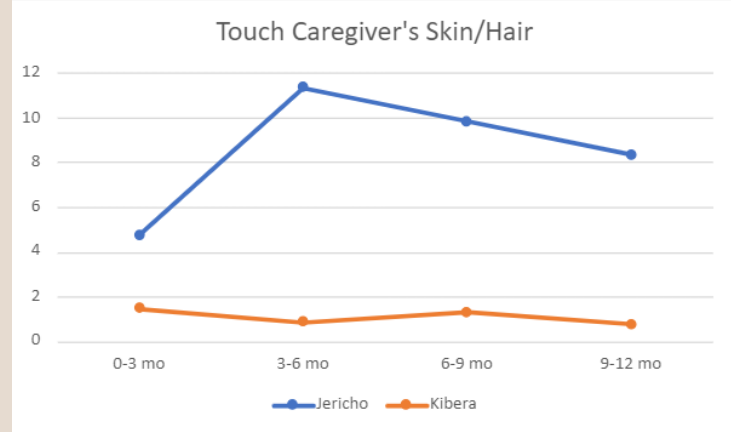
- Many behaviors varied considerably with age
  - Example:
    - Mouth to caregiver's hair/skin
  - This trend makes sense/was expected



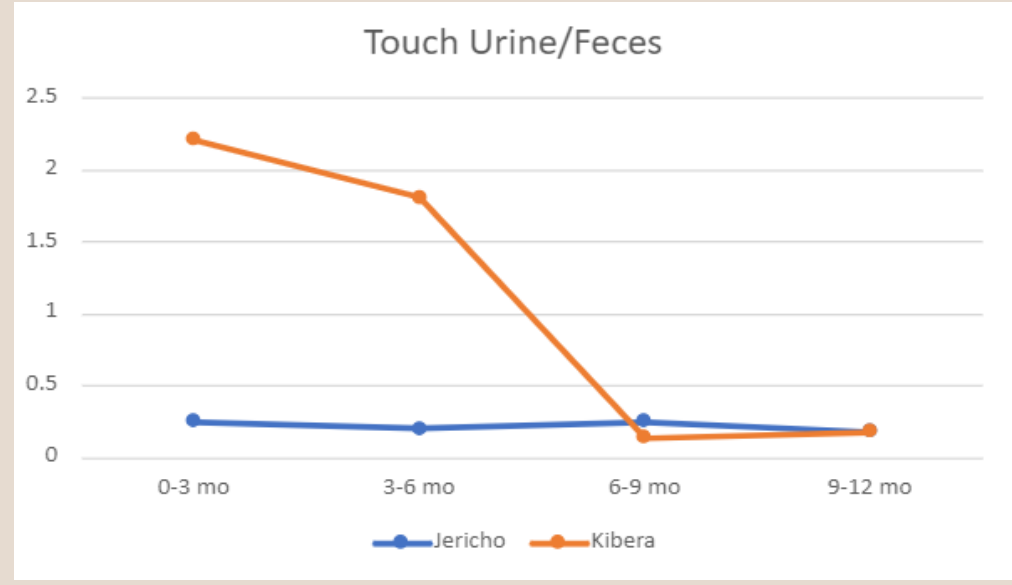
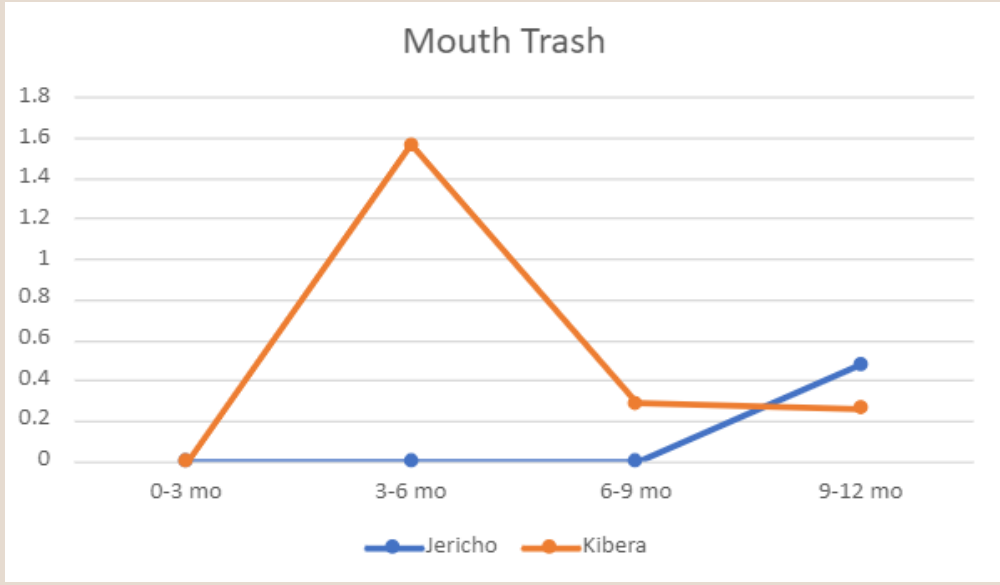
# Results/Analysis

- Some behaviors are quite concerning and occur at high rates:
  - Examples: among some groups, behaviors such as mouthing animal feces had rates up to 3.44 times per hour
- Other concerning behaviors occurred at lower rates:
  - Examples: rates for mouthing trash were mostly 0, with the highest non-zero rate being 1.57 times per hour
- Some behaviors varied considerably between Jericho and Kibera:
  - Social evolution & development
  - Less poverty in Jericho
  - Extreme poverty in Kibera

# Neighborhood Differences



# Neighborhood Differences





# Conclusion

- We found models for the rates of 42 behaviors
- Vast majority grouped by age and neighborhood
- Behaviors, wealth, & Jericho
- Behaviors, less wealth, & Kibera

# Future Steps

- Combine our results with microbiological data:
  - Soil samples, water samples, caregiver hand rinses, toy rinses
  - Transmission efficiency
  - Identify how children are getting exposed

# Acknowledgments

Dr. Daniel Sewell – Mentor

Dr. Kelly Baker – Microbiologist and  
Epidemiologist

Dr. Gideon Zamba – Program Director

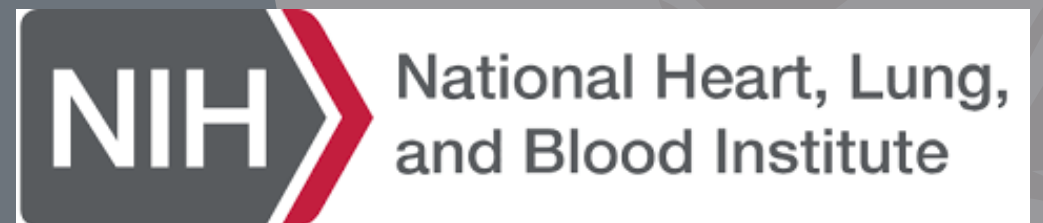
Terry Kirk – Program Coordinator

Daniel I. Kakou – Graduate Student

NHLBI Grant #HL161716-01 - Sponsor



<https://lacienciadelcafe.com.ar/check-which-frame-suits-my-face/university-of-iowa-wikipedia-pp-33586650>



Advancing Heart, Lung, Blood, and Sleep Research & Innovation | NHLBI, NIH

# References

- De Nisco, Nicole J., et al. “The Biochemistry of Sensing: Enteric Pathogens Regulate Type III Secretion in Response to Environmental and Host Cues.” *MBio*, vol. 9, no. 1, American Society for Microbiology, Mar. 2018, <https://doi.org/10.1128/mbio.02122-17>.
- Gorbach, L. “Microbiology of the Gastrointestinal Tract.” *Medical Microbiology* -NCBI Bookshelf, 1996, [www.ncbi.nlm.nih.gov/books/NBK7670](http://www.ncbi.nlm.nih.gov/books/NBK7670).
- Guillaume DA, Justus OOS, Ephantus KW. Factors influencing diarrheal prevalence among children under five years in Mathare Informal Settlement, Nairobi, Kenya. *J Public Health Afr*. 2020 Oct 29;11(1):1312. doi: 10.4081/jphia.2020.1312. PMID: 33209237; PMCID: PMC7649734.

# References

Haushofer, Johannes, et al. Water Treatment and Child Mortality: Evidence From Kenya. 1 Nov. 2021, <https://doi.org/10.3386/w29447>.

Kibera UK. "Some Facts and Stats About Kibera, Kenya | Kibera UK." Kibera UK, 14 Feb. 2018, [www.kibera.org.uk/facts-info](http://www.kibera.org.uk/facts-info).

Webale, M. K., Wanjala, C., Guyah, B., Shaviya, N., Munyekenye, G. O., Nyanga, P. L., Marwa, I. N., Kagoiyo, S., Wangai, L. N., Webale, S. K., Kamau, K., & Kitungulu, N. (2020). Epidemiological patterns and antimicrobial resistance of bacterial diarrhea among children in Nairobi City, Kenya. *Gastroenterology and hepatology from bed to bench*, 13(3), 238–246.

Thank you!



&

