Investigating the Relationship Between Food Contamination and Enteric Pathogen Infections in Infants Living in Low-to-middle-income Countries

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What is an Enteric Infection?

- **Causes:** Bacteria, viruses, parasites and fungi
- **Transmission:** Eating/drinking contaminated food/water and fecal transmission
- **Symptoms of infection:** Abdominal pain, nausea/vomiting, diarrhea, reduced appetite, among others
- **Ex:** Bacterium E.coli

https://health.mil/Military-Health-Topics/Combat-Support/Armed-Forces-Health-Surveillance-Branch/Global-Emerging-Infections-Surveillance-and-Response/Enteric-Infections

Why is this important?

- Dozens of pathogens are transmitted by fecal contamination in low-to-middle income countries causing:
    - 2.5 billion episodes of diarrhea
    - 580,000 deaths of children under five years per year
    - 40% of global health impact of foodborne illness

Research Questions

Question 1: How are infants in low-to-middle income areas colonized with pathogens?

Question 2: Can milk contamination predict colonization?

Safe Start and Market 2 Mouth Studies

Q1 Data: Safe Start Study

- Evaluates impact of a caregiver food hygiene behavior change intervention at preventing enteric infection in infants
- Endline data - PCR data from stool samples collected after 9 months

Q2 Data: Market 2 Mouth Study (M2M)

- Evaluates the impact of Safe Start intervention at preventing transmission of pathogens from dairy to infant food
- Midline data - Culture data from food samples after 8 months

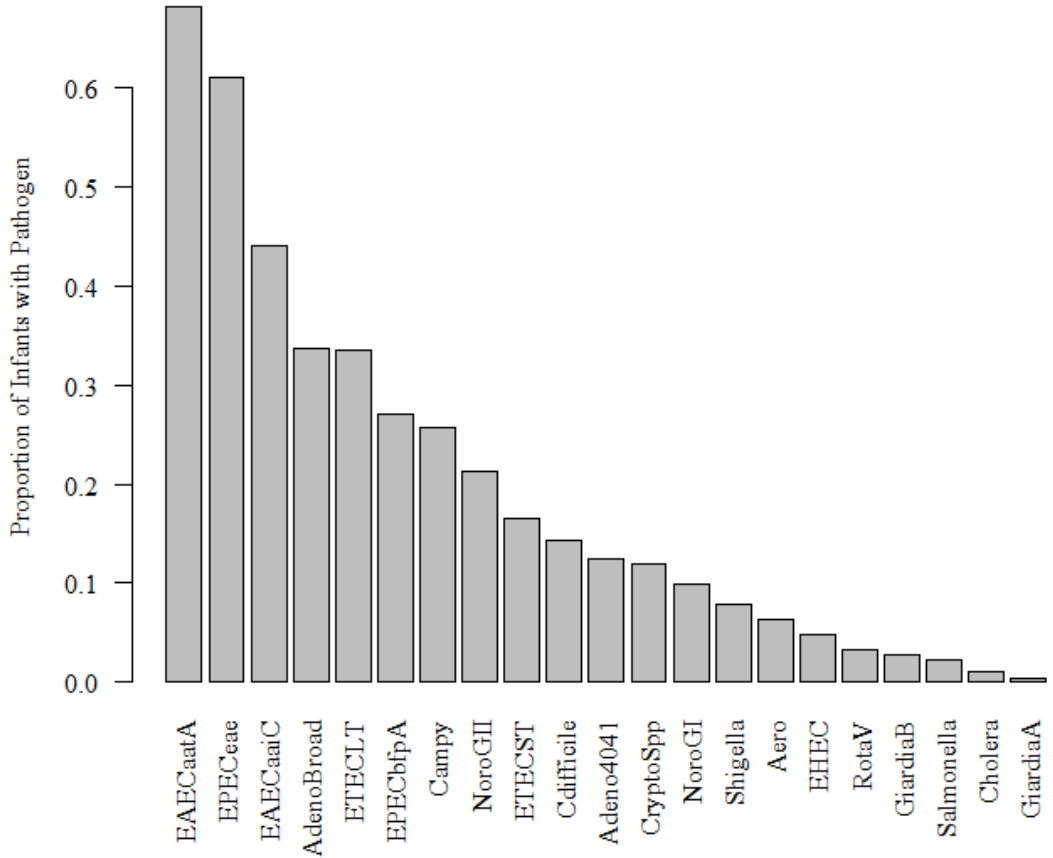
Data

- Based off of these two recent studies in Kenya on infant food and infections, we studied relationships between food and infections.
- Sample population: Infants at 8-9 months of age in Kenya.
- Only caregivers who fed their infants milk or food made with milk, (milk tea, milk porridge, etc.) are included in the M2M study.
- Some pathogens carry multiple pathogenic genes at once
  - EPECbfpA vs EPECeae

How are infants colonized?

Analysis done using endline infant stool PCR samples

Prevalence of Endline Data



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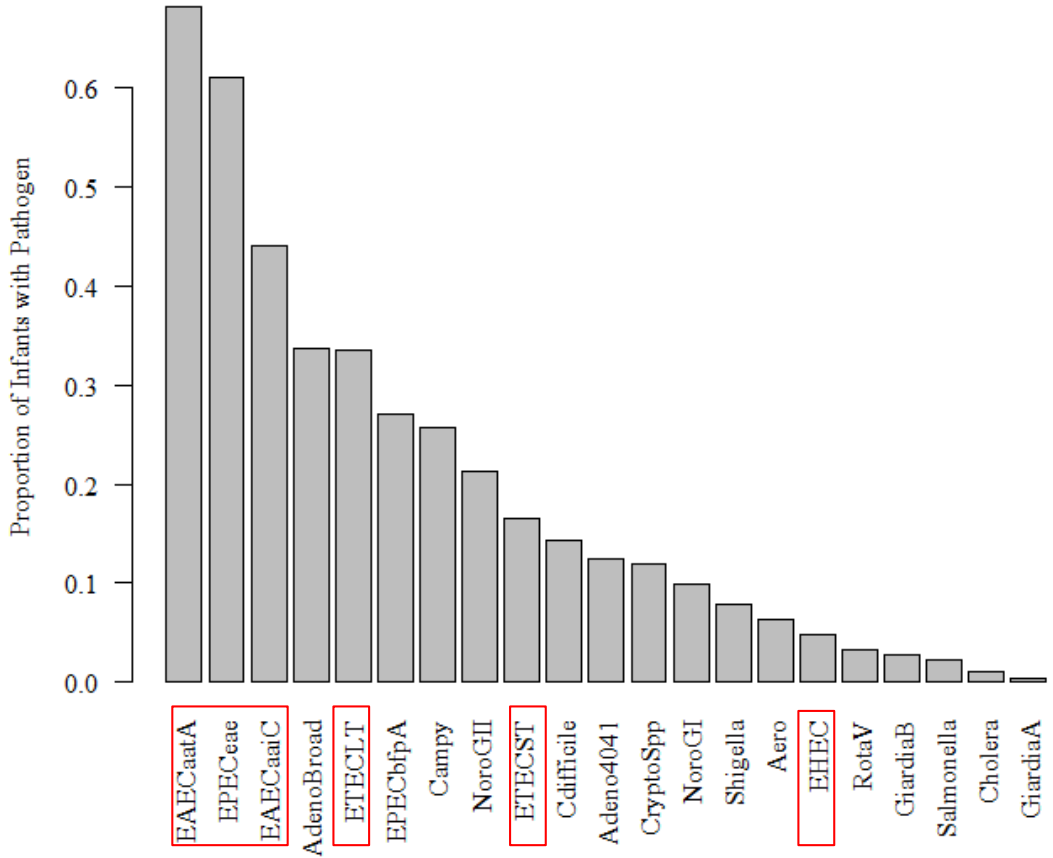

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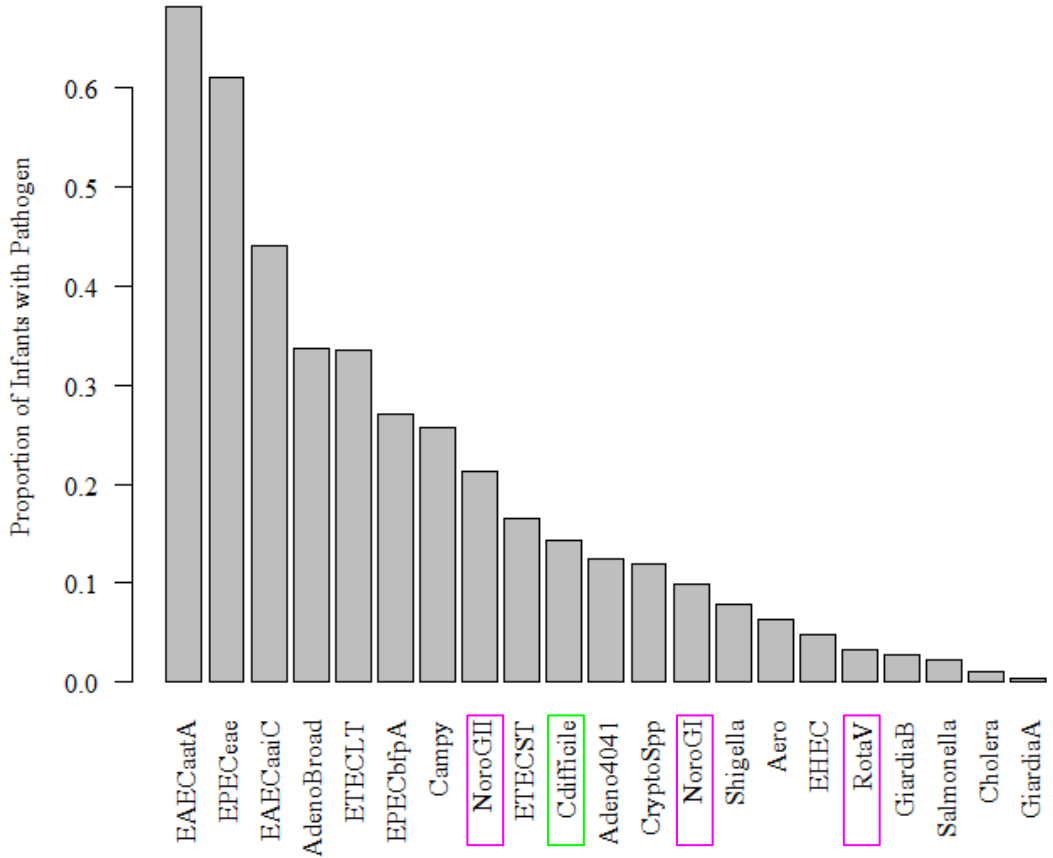

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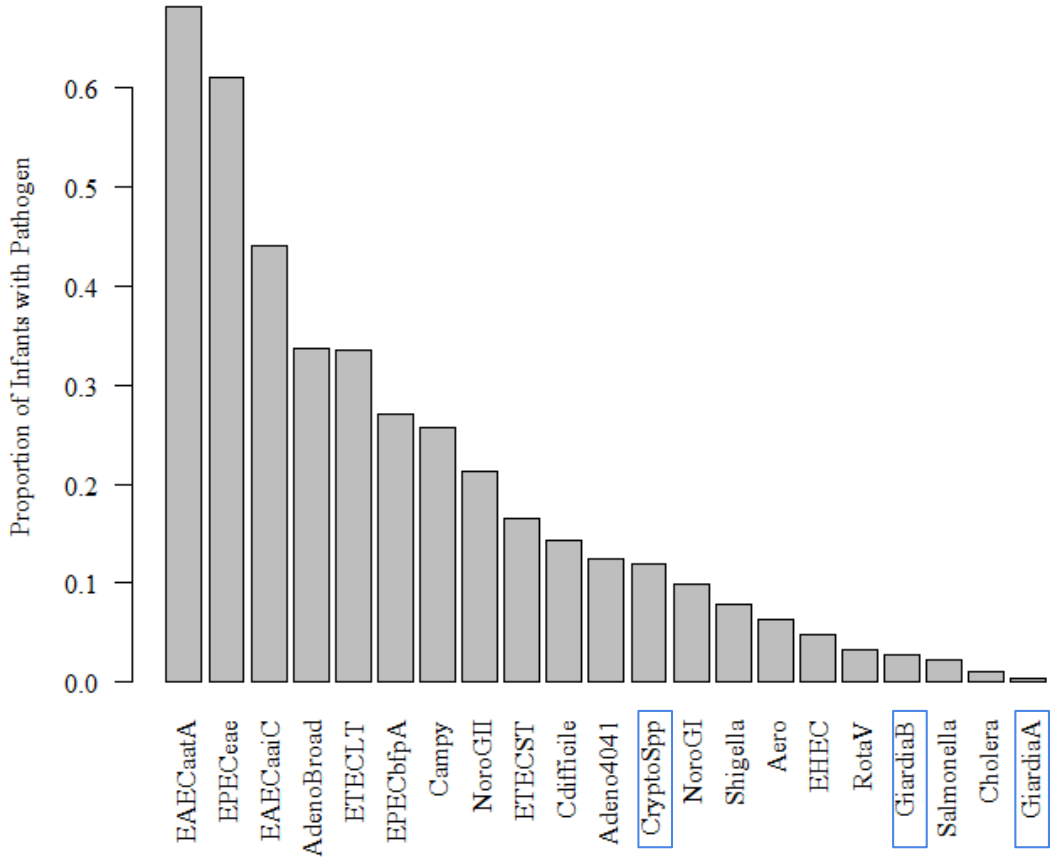
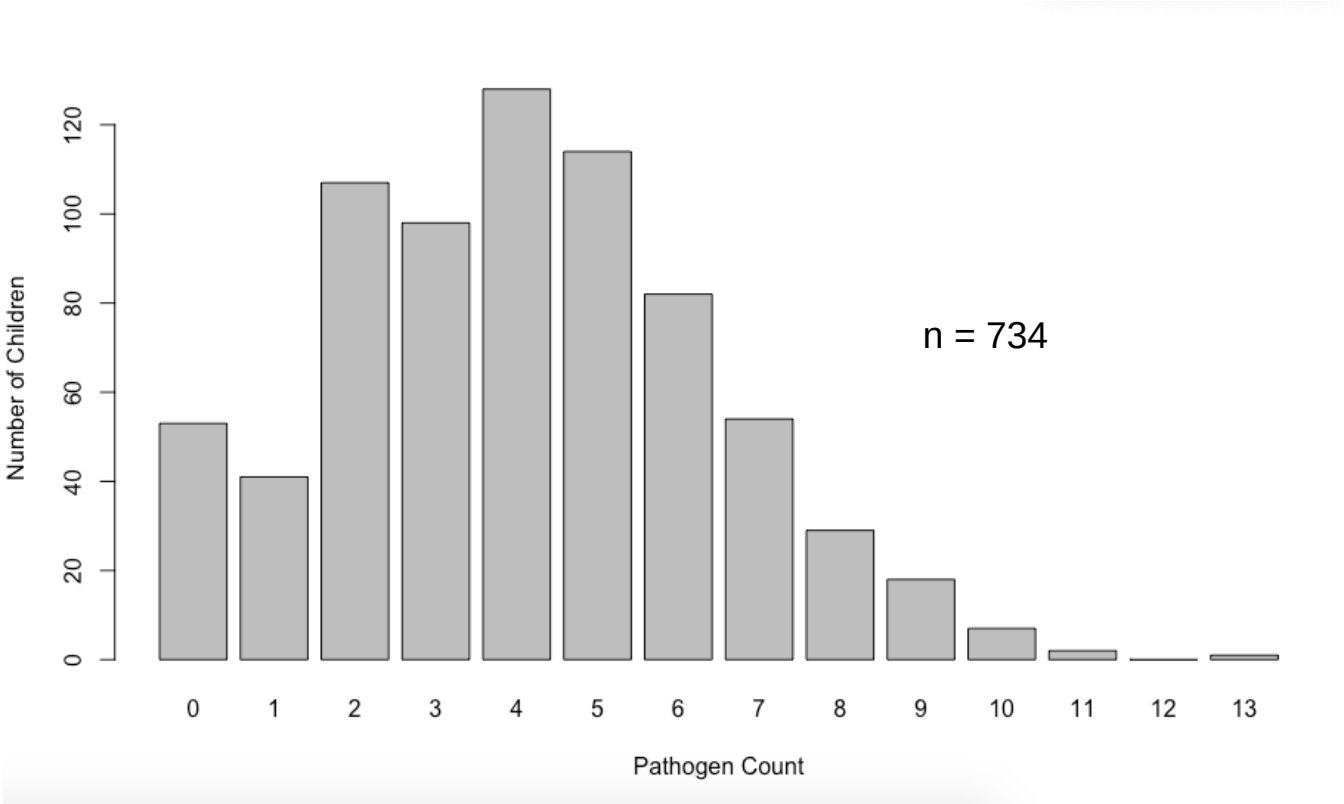
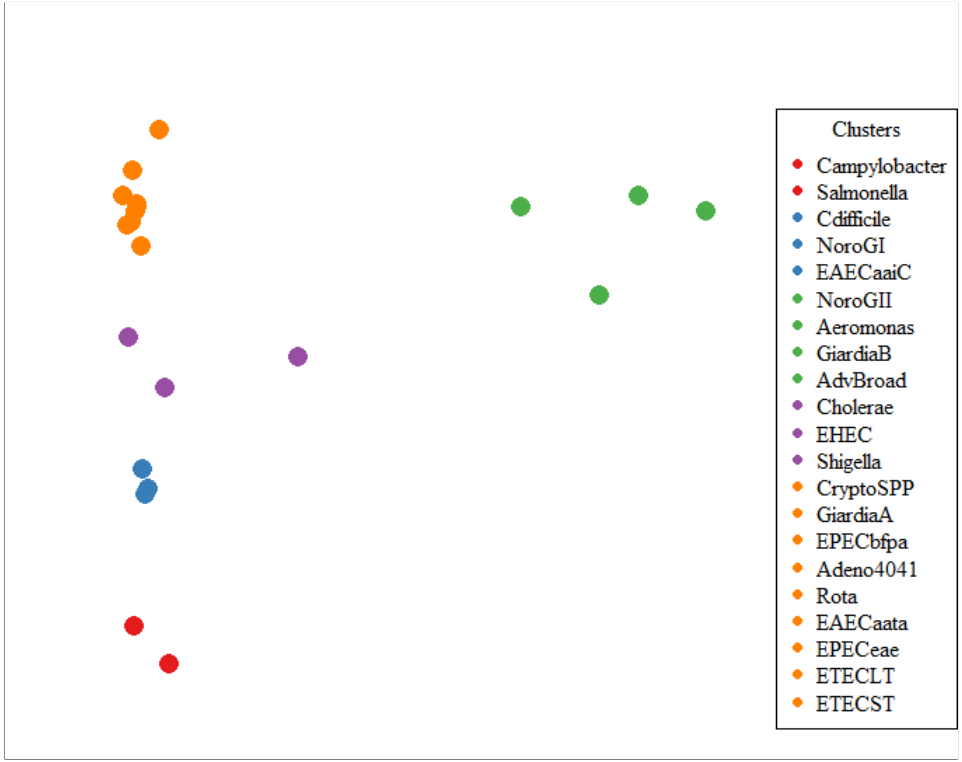


Diversity of Endline Data

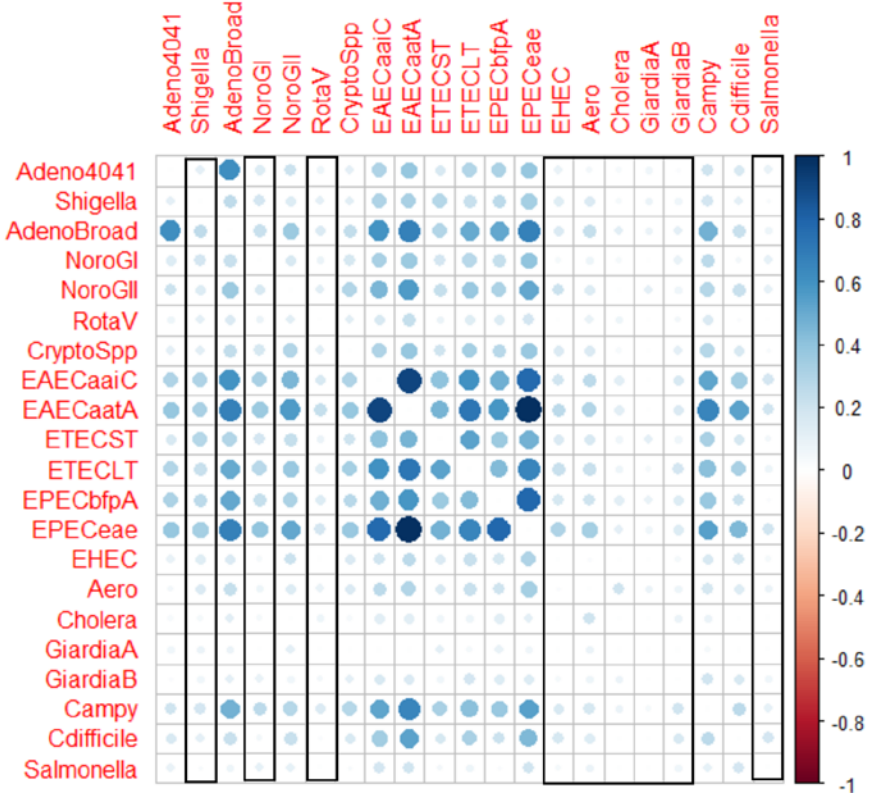


Principal Component Analysis

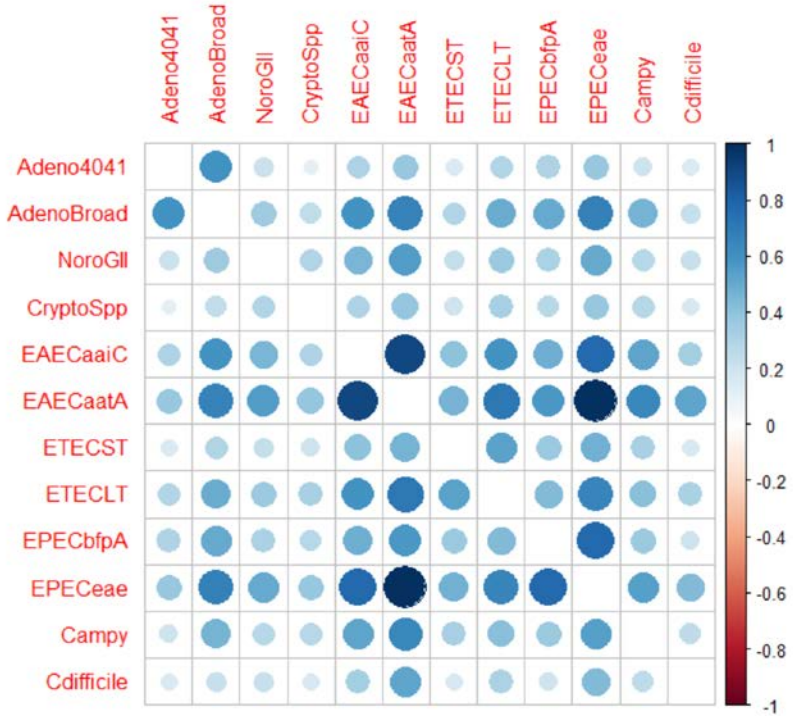
- If we are to plot all 21 pathogens, we would need 21 dimensions
  - PCA reduces this to 2 dimensions/loadings
- K-means assigns each pathogen to a cluster



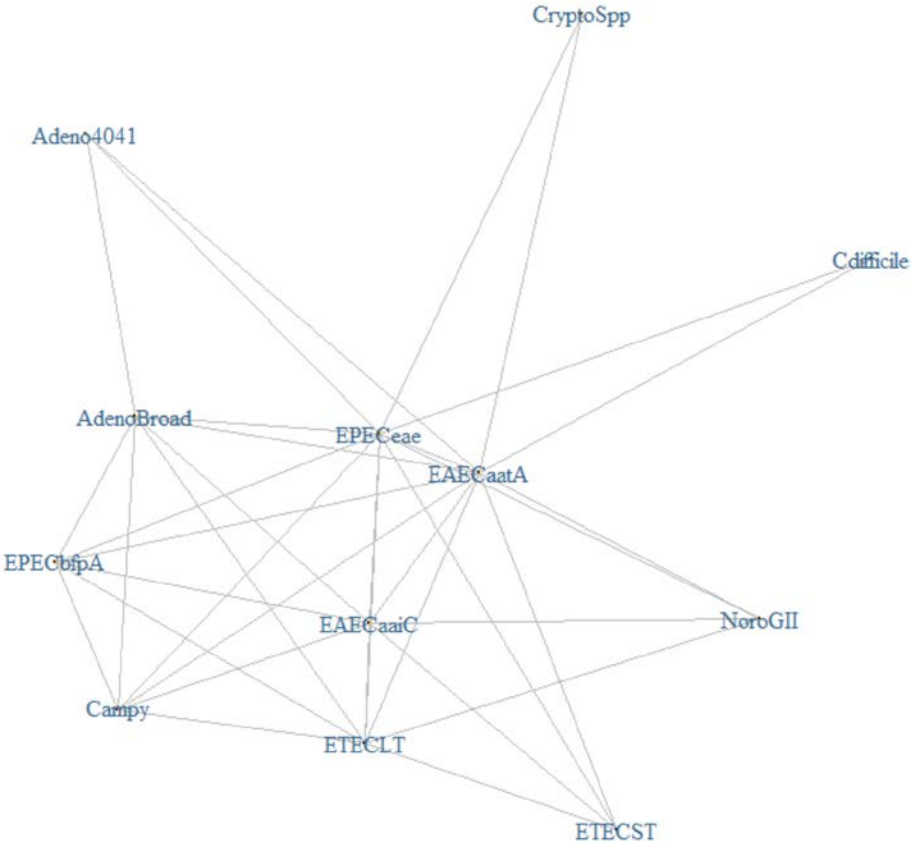
Weighted Adjacency Matrix



Weighted Adjacency Matrix



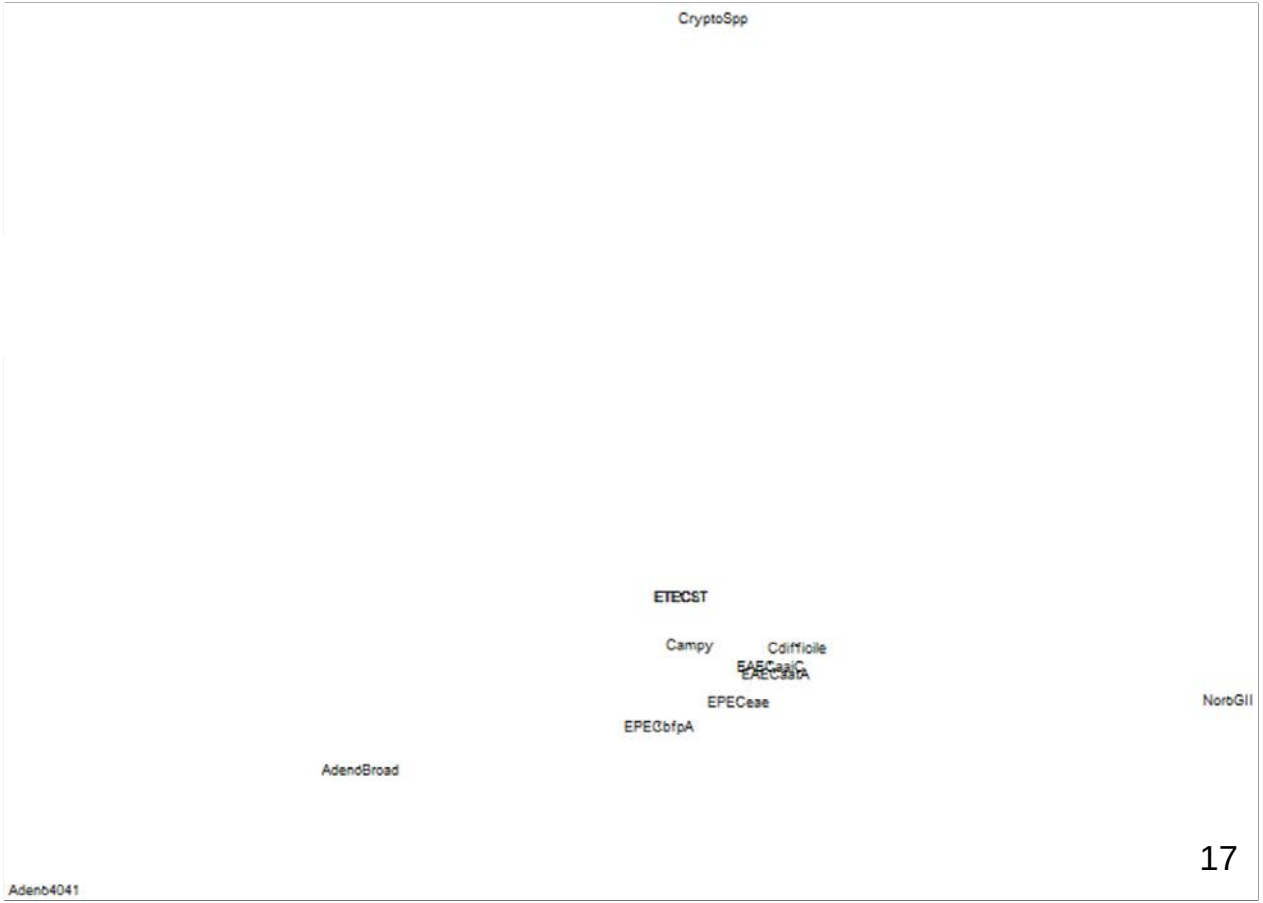
Network


CryptoSpp
Adeno4041
Cdifficile
AdenoBroad
EPECeae
EAECaatA
EPECbfpA
EAECaaiC
NoroGII
Campy
ETECLT
ETECST

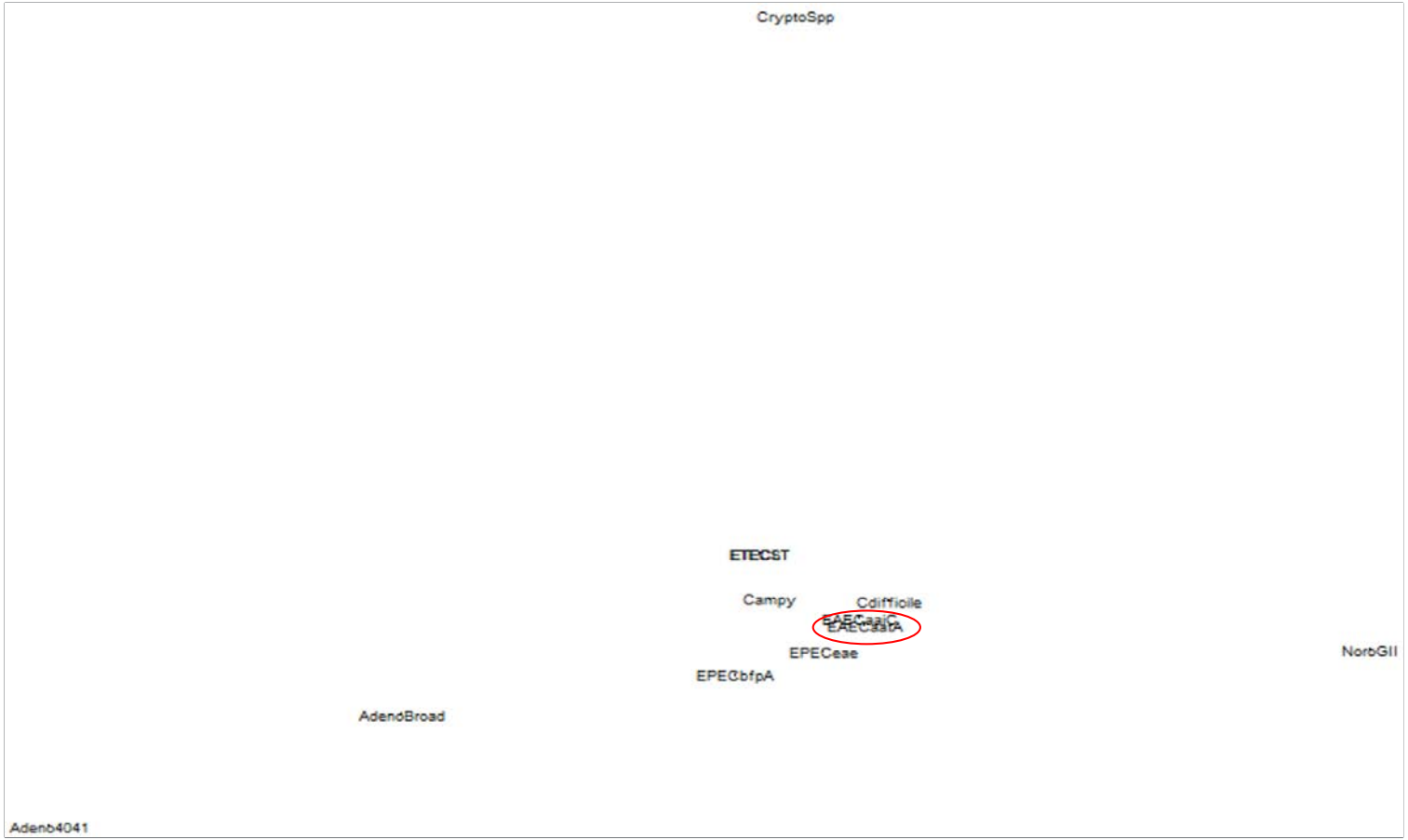
Latent Space Model

$$\text{logit}(\text{Prob}(i \text{and} j \text{co-occur}) = \text{Intercept} + s_i + s_j - d(Z_i, Z_j)$$

- Models introduced by Hoff et al. in 2002, and position estimation was done through a Markov chain Monte-Carlo algorithm.



Latent Position



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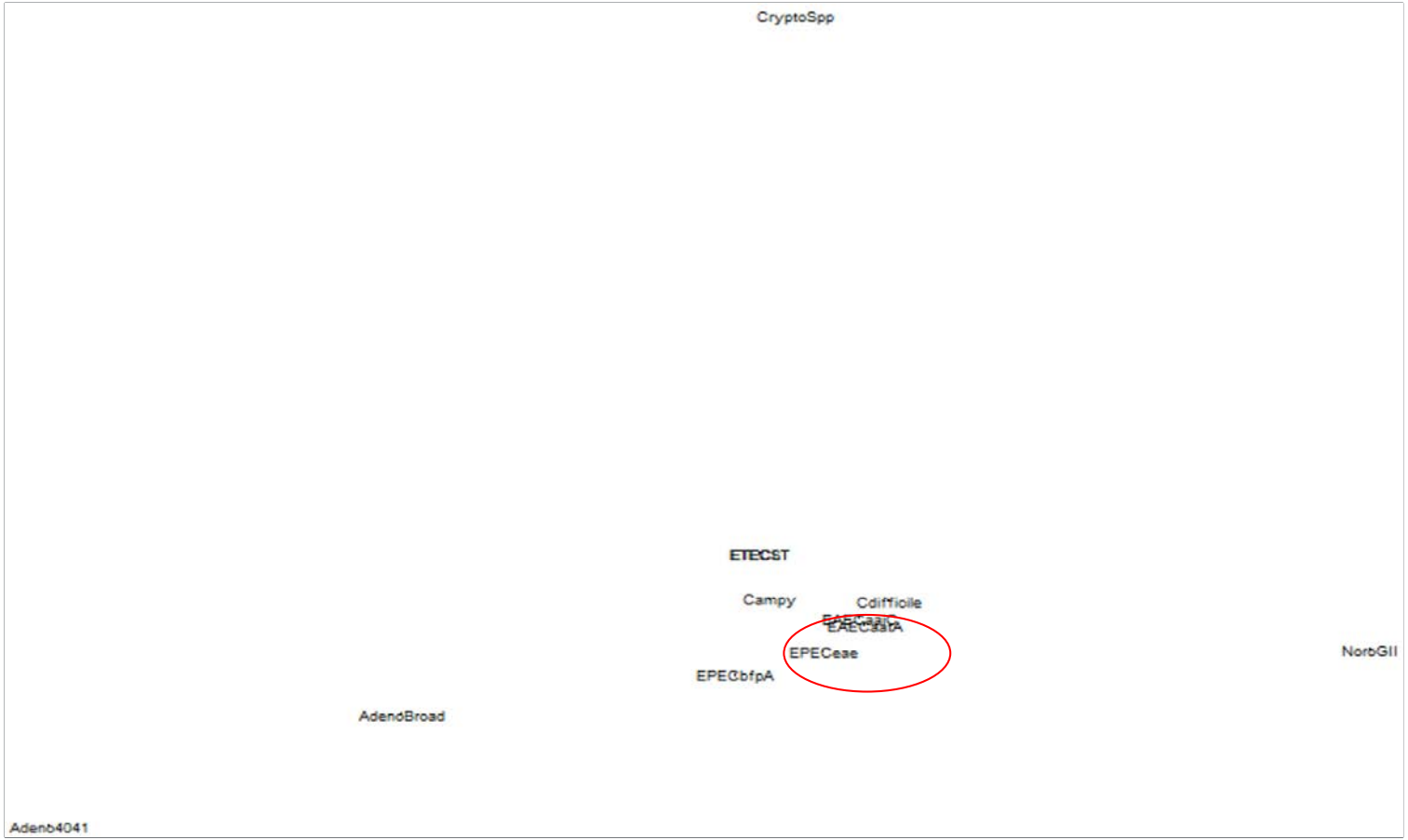
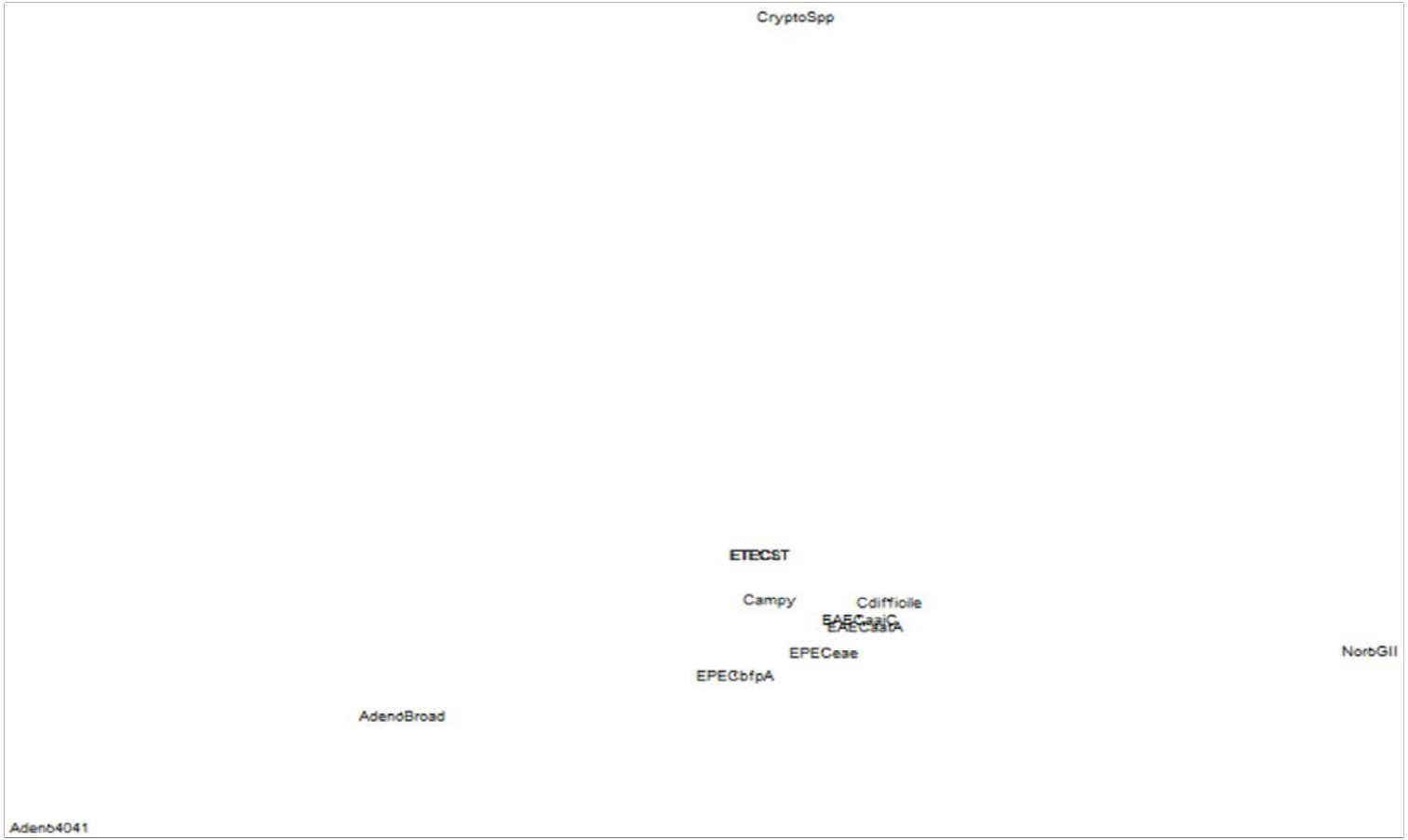


Latent Position



Can milk contamination predict colonization?

Analysis done using midline culture and self reported diarrhea data

Logistic Regression

- Binary outcome: self-reported diarrhea
- Culture data on Ecoli, Shigella, EHEC, entero
- Used logistic regression
  - P(diarrhea) = f(Ecoli, Shigella, EHEC, entero)

Logistic Regression

Pathogens	Estimates	P-value
(Intercepts)	*-1.595e+00*	*< 2e-16*
Shigella	5.055e-06	0.309
Ecoli	-1.521e-03	0.739
EHEC	7.232e-07	0.719
entero	5.437e-07	0.899

- The presence of each pathogen has little to no effect on the odds of the individual having diarrhea.

Conclusions

- **Prevalence:** Infants in low-income areas are colonized with many diverse pathogens which are known to cause enteric diseases.
  - Most prevalent: EAECaatA and EPECeae
  - Least Prevalent: Salmonella, Cholera and Giardia

- **PCA:** The pathogens we studied can be divided into 5 different clusters

- **Latent Space:** The latent space showed that there are strong indications of symbiotic relationships between certain pathogens that merit further exploration.

- **Logistic Regression:** Our data suggest that diarrhea is not an effective tool for identifying colonization of enteric pathogens in children.

Acknowledgements

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