Behavioral and Environmental Pathways and Enteric Pathogen Profiles in Infants in Kisumu, Kenya

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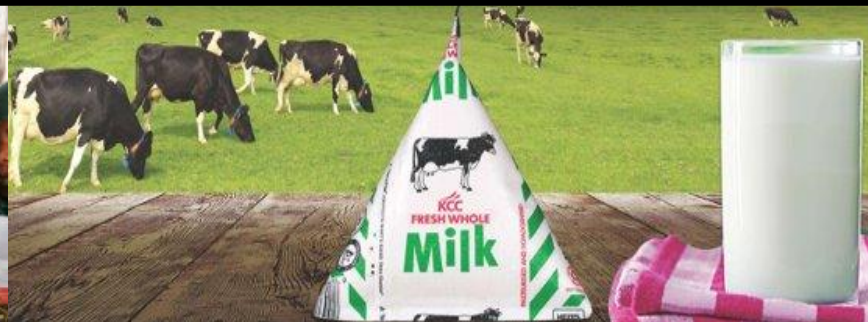


Enteric Pathogens Infection

***Enteric Pathogen*: a microbe that affects the intestine and can make a person sick**

- Acquired through contaminated food and water, by contact with animals or their environment, or with the feces of an infected person (CDC 2021)

<u>Impacts:</u>

- In low to middle-income countries, numerous viral, bacterial and protozoan enteric pathogens are collectively causing:
- 2.5 billion episodes of diarrhea
  - 580,000 deaths in children under five years of age each year.
- More than a third of all children are infected within the first year of life by one or more pathogens

CDC 2021

Safe Start Program

- Data from study on 6-month old infants in Kisumu, Kenya enrolled in a Safe-Start Program
- Relationship between enteric infection, diarrhea and the following factors:
  - Household water access and treatment
  - Animal vectors
  - Sanitation
  - Hand washing practices
  - Supplemental feeding
  - Flooring

Baker et. al 2021

1. Do there exist clusters of children with similar exposure patterns through their household behaviors and environment?
2. If such clusters exist, are these exposure patterns leading to different enteric pathogen profiles?

Population of Interest: Infacts from 0-6 months of age in Kisumu,Kenya enrolled in the Safe Start Program

Behavioral and Environmental Data

Environmental Variables

Behavioral Variables

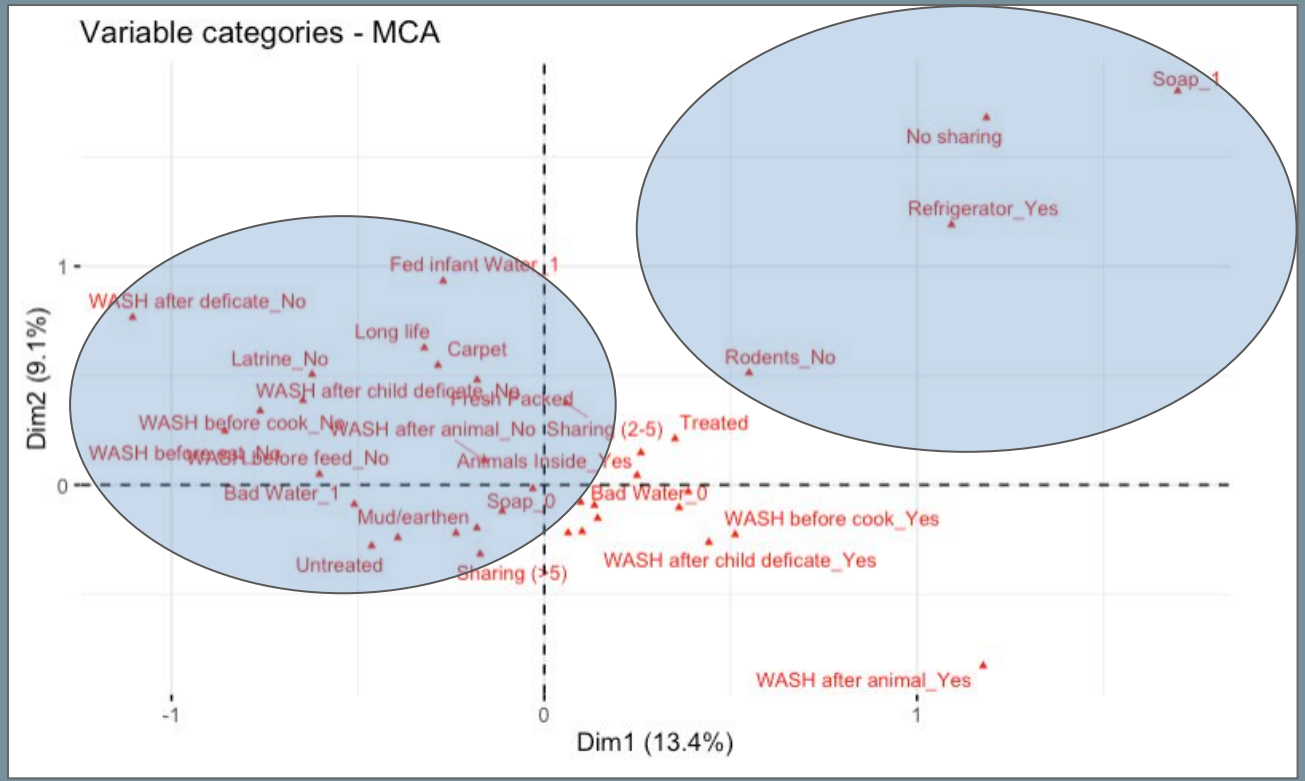
	Overall (N=866)
Latrine	
No	117 (13.5%)
Yes	749 (86.5%)
Flooring	
Carpet	198 (22.9%)
Hard	595 (68.7%)
Mud/earthen	73 (8.4%)
Sharing a Latrine	
No sharing	83 (9.6%)
Sharing (>5)	626 (72.3%)
Sharing (2-5)	157 (18.1%)
Rodents	
No	261 (30.1%)
Yes	605 (69.9%)
Animals Inside	
No	774 (89.4%)
Yes	92 (10.6%)
WASH after deficate	
No	94 (10.9%)
Yes	772 (89.1%)
WASH after child deficate	
No	351 (40.5%)
Yes	515 (59.5%)
WASH after animal	
No	762 (88.0%)
Yes	104 (12.0%)
Soap	
0	812 (93.8%)
1	54 (6.2%)
WASH before eat	
No	257 (29.7%)
Yes	609 (70.3%)
WASH before feed	
No	338 (39.0%)
Yes	528 (61.0%)
WASH before cook	
No	348 (40.2%)
Yes	518 (59.8%)
Refrigerator	
No	743 (85.8%)
Yes	123 (14.2%)
Milk Type	
Fresh Packed	79 (9.1%)
Long life	155 (17.9%)
No milk	632 (73.0%)
Fed infant Water	
0	701 (80.9%)
1	165 (19.1%)
Bad Water	
0	582 (67.2%)
1	284 (32.8%)
Treated Water	
Treated	493 (56.9%)
Untreated	373 (43.1%)

Overview Methods: Behavioral and Environmental Variable Relationships

1. Observe Variable Groupings:
    a. Multiple Correspondence Analysis (MCA),
    b. Phi Coefficient Matrix
2. Observe Individual Clusters:
    a. Latent Class Analysis (LCA)

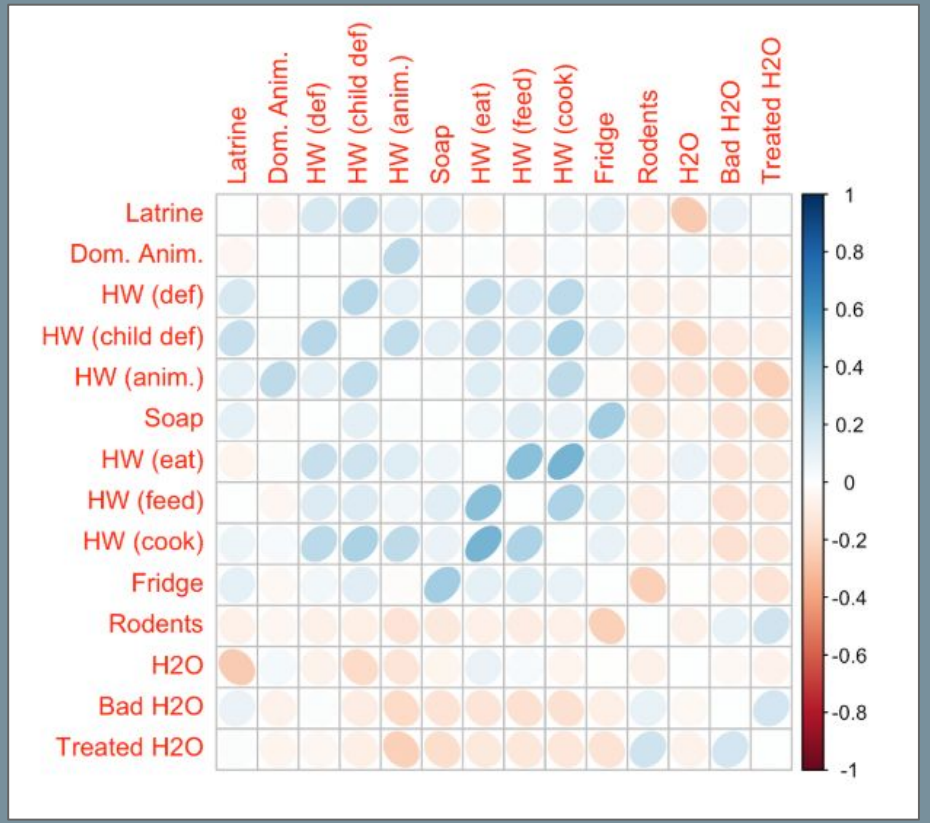
Behavior and Environmental Variable Relationships

Multiple Correspondence Analysis (MCA)



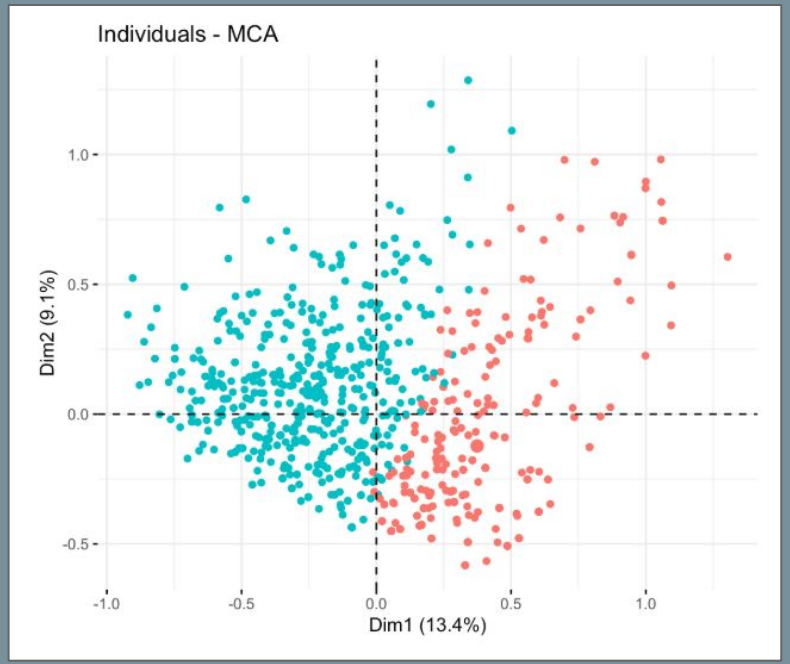
Behavior and Environmental Variable Relationships

Phi Coefficient Matrix

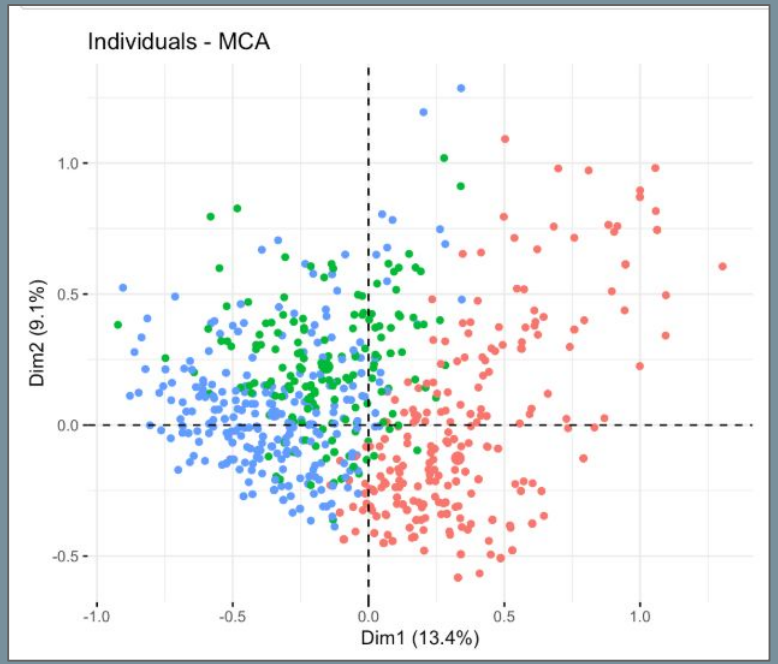


Behavioral and Environmental Clustering Among Individuals: Latent Class Analysis (LCA)

Two Cluster (nclass=2)



Three Cluster (nclass=3)



Wealth Index Quartile and Clusters

Cluster 1: “Good”
- Wealthier Cluster

	1 (N=370)	2 (N=256)	3 (N=152)	Overall (N=778)
Wealth Index				
Highest quintile	125 (33.8%)	20 (7.8%)	13 (8.6%)	158 (20.3%)
Low-middle	51 (13.8%)	64 (25.0%)	35 (23.0%)	150 (19.3%)
Middle	67 (18.1%)	55 (21.5%)	36 (23.7%)	158 (20.3%)
Poorest	43 (11.6%)	73 (28.5%)	35 (23.0%)	151 (19.4%)
Upper-Middle	84 (22.7%)	44 (17.2%)	33 (21.7%)	161 (20.7%)

Cluster 2: “Not Good”
- Poorer Cluster

Cluster 3: “Not Good”
- Poorer Cluster

	1 (N=397)	2 (N=301)	3 (N=168)	Overall (N=866)
Latrine				
No	5 (1.3%)	27 (9.0%)	85 (50.6%)	117 (13.5%)
Yes	392 (98.7%)	274 (91.0%)	83 (49.4%)	749 (86.5%)
Flooring				
Carpet	54 (13.6%)	111 (36.9%)	33 (19.6%)	198 (22.9%)
Hard	315 (79.3%)	173 (57.5%)	107 (63.7%)	595 (68.7%)
Mud/earthen	28 (7.1%)	17 (5.6%)	28 (16.7%)	73 (8.4%)
Sharing a Latrine				
No sharing	55 (13.9%)	13 (4.3%)	15 (8.9%)	83 (9.6%)
Sharing (>5)	278 (70.0%)	228 (75.7%)	120 (71.4%)	626 (72.3%)
Sharing (2-5)	64 (16.1%)	60 (19.9%)	33 (19.6%)	157 (18.1%)
Rodents				
No	143 (36.0%)	69 (22.9%)	49 (29.2%)	261 (30.1%)
Yes	254 (64.0%)	232 (77.1%)	119 (70.8%)	605 (69.9%)
Animals Inside				
No	358 (90.2%)	274 (91.0%)	142 (84.5%)	774 (89.4%)
Yes	39 (9.8%)	27 (9.0%)	26 (15.5%)	92 (10.6%)
WASH after deficate				
No	1 (0.3%)	57 (18.9%)	36 (21.4%)	94 (10.9%)
Yes	396 (99.7%)	244 (81.1%)	132 (78.6%)	772 (89.1%)
WASH after child deficate				
No	42 (10.6%)	183 (60.8%)	126 (75.0%)	351 (40.5%)
Yes	355 (89.4%)	118 (39.2%)	42 (25.0%)	515 (59.5%)
WASH after animal				
No	297 (74.8%)	299 (99.3%)	166 (98.8%)	762 (88.0%)
Yes	100 (25.2%)	2 (0.7%)	2 (1.2%)	104 (12.0%)
Soap				
0	354 (89.2%)	291 (96.7%)	167 (99.4%)	812 (93.8%)
1	43 (10.8%)	10 (3.3%)	1 (0.6%)	54 (6.2%)
WASH before eat				
No	19 (4.8%)	224 (74.4%)	14 (8.3%)	257 (29.7%)
Yes	378 (95.2%)	77 (25.6%)	154 (91.7%)	609 (70.3%)
WASH before feed				
No	80 (20.2%)	211 (70.1%)	47 (28.0%)	338 (39.0%)
Yes	317 (79.8%)	90 (29.9%)	121 (72.0%)	528 (61.0%)

LCA Cluster Contributions

Cluster 1: "Good"
- Better environment and hygiene
- 397 Individuals

Cluster 2: "Not Good"
- Bad environment and bad hygiene
- 301 Individuals

Cluster 3: "Not Good"
- Bad environment but better hygiene
- 168 Individuals

	1 (N=397)	2 (N=301)	3 (N=168)	Overall (N=866)
WASH before cook				
No	23 (5.8%)	248 (82.4%)	77 (45.8%)	348 (40.2%)
Yes	374 (94.2%)	53 (17.6%)	91 (54.2%)	518 (59.8%)
Refrigerator				
No	308 (77.6%)	275 (91.4%)	160 (95.2%)	743 (85.8%)
Yes	89 (22.4%)	26 (8.6%)	8 (4.8%)	123 (14.2%)
Milk Type				
Fresh Packed	26 (6.5%)	20 (6.6%)	33 (19.6%)	79 (9.1%)
Long life	34 (8.6%)	44 (14.6%)	77 (45.8%)	155 (17.9%)
No milk	337 (84.9%)	237 (78.7%)	58 (34.5%)	632 (73.0%)
Fed infant Water				
0	370 (93.2%)	279 (92.7%)	52 (31.0%)	701 (80.9%)
1	27 (6.8%)	22 (7.3%)	116 (69.0%)	165 (19.1%)
Bad Water				
0	307 (77.3%)	141 (46.8%)	134 (79.8%)	582 (67.2%)
1	90 (22.7%)	160 (53.2%)	34 (20.2%)	284 (32.8%)
Treated Water				
Treated	262 (66.0%)	126 (41.9%)	105 (62.5%)	493 (56.9%)
Untreated	135 (34.0%)	175 (58.1%)	63 (37.5%)	373 (43.1%)

Overview Methods: Cluster relationship with Pathogens in Infants

1. Self-Reported Diarrhea and Cluster Relationship:
    a. Logistic Regression Model
    b. Likelihood Ratio Test (LRT)
2. Pathogen Diversity and Cluster Relationship:
    a. Poisson Regression Model
    b. Likelihood Ratio Test (LRT)

Cluster relationship with Self-Reported Diarrhea

Logistic Regression Model:

Null Hypothesis:
H_0: $P(y=1|c_1) = P(y=1|c_2) = P(y=1|c_3)$

Likelihood Ratio Test for Diarrhea

#Df	LogLik	Df	Chisq	Pr(>Chisq)
3	-318.1509	NA	NA	NA
1	-325.5839	-2	14.86586	0.0005915

At a 5% significance level, there is sufficient evidence (p= 0.0059) to conclude that the cluster assignments help predict Self-Reported Diarrhea outcomes.

Subgroup Analysis:

Diarrhea Between Cluster Assignments 2 and 3

#Df	LogLik	Df	Chisq	Pr(>Chisq)
1	-200.5076	NA	NA	NA
2	-200.2879	1	0.4394316	0.5073969

Despite hygiene differences in Cluster 2 and 3, there is not enough evidence to suggest a difference in Diarrhea outcome between the two clusters.

Cluster relationship with Pathogen Diversity

Pathogen Diversity: The number of pathogens existing in a body

Poisson Regression Model:

Null Hypothesis:

H_o: $E(y_i|c_1) = E(y_i|c_2) = E(y_i|c_3)$

Likelihood Ratio Test for Pathogen Diversity

#Df	LogLik	Df	Chisq	Pr(>Chisq)
1	-1307.093	NA	NA	NA
3	-1305.416	2	3.352141	0.1871078

At a 5% significance level, there is not evidence suggesting that cluster assignments helps predict pathogen diversity.

	1 (N=368)	2 (N=256)	3 (N=152)	Overall (N=776)
Diversity				
0	47 (12.8%)	34 (13.3%)	17 (11.2%)	98 (12.6%)
1	95 (25.8%)	72 (28.1%)	31 (20.4%)	198 (25.5%)
2	109 (29.6%)	60 (23.4%)	45 (29.6%)	214 (27.6%)
3	75 (20.4%)	53 (20.7%)	31 (20.4%)	159 (20.5%)
4	29 (7.9%)	24 (9.4%)	19 (12.5%)	72 (9.3%)
5	9 (2.4%)	10 (3.9%)	7 (4.6%)	26 (3.4%)
6	4 (1.1%)	2 (0.8%)	2 (1.3%)	8 (1.0%)
7	0 (0%)	1 (0.4%)	0 (0%)	1 (0.1%)
Self-Reported Diarrhea				
0	332 (90.2%)	209 (81.6%)	120 (78.9%)	661 (85.2%)
1	36 (9.8%)	47 (18.4%)	32 (21.1%)	115 (14.8%)

Conclusion

- There are evident and distinct clusters in behavioral and environmental pathways
- Clusters are significant predictors of self-reported diarrhea → a serious result of illness and pathogen presence in infants
- Clusters are not significant predictors of pathogen diversity

Limitations:

- Polymer Chain Reaction (PCR) detects both live and dead pathogens → potentially miscounting the active pathogen population in infants
- More pathogens need to be tested

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NIH National Heart, Lung, and Blood Institute

Work Cited

Baker, Kelly, et. al. 2021. “Socio-economic and environmental exposure pathways associated with diarrhea and enteric pathogen detection in six month old urban Kenyan infants: a cross-sectional study” .

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