"Risk Factors Associated with Environmental Enteric Dysfunction (EED) in Rural Southwestern Uganda"

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Background

- Environmental enteric dysfunction (EED) refers to an incompletely defined syndrome of mucosal inflammation, reduced intestinal absorptive capacity, and reduced barrier function. It is widely observed in children as well as adults throughout the developing world.[1]
- Although EED is an asymptomatic condition, it is significant due to its potential association with negative growth outcomes, especially with regard to stunting in young children.[23]
- Despite being a recognized phenomenon since the 1960s, the causes of EED remain extremely limited. However, several recent studies have indicated that EED is likely the result of exposure to enteropathogens and enterotoxins as a result of repeated exposure to unsanitary environmental conditions.
- Specifically, recent studies have indicated that poor household water quality[4], a lack of handwashing infrastructure[4], mouthing behavior[5], and/or exposure to animals[6] may be associated with EED.

Objectives and Methods

- The main objective of this study is to investigate the relationship between environmental factors and EED in young children, 12-16 months of age, living in rural Southwestern Uganda.
- The assessment was a sub-study of the Uganda Birth Cohort study, undertaken from 2014-2015 by the Feed the Future Innovation Lab for Nutrition based at Tufts University.
- In total, 385 children from seven sub-counties in Southwestern Uganda who met the inclusion criteria were randomly selected for participation in the study.
- EED was assessed at 12-16 months using a lactulose: mannitol (L:M) test. For the L:M test, children consumed 20 ml. of solution containing 5 grams of lactulose and 1 gram of mannitol. All urine was collected using pediatric urine collection bags for a minimum of four hours, and 1.5 ml. aliquots were stored at a minimum of -20°C until analysis. Levels of the two sugars were analyzed using validated LC-MS methods at Baylor College of Medicine.
- Data on household environmental conditions were extracted from the 6 month infant age time point of the Uganda Birth Cohort study. Water quality was assessed using the Aquagenx Compartment Bag Test (CBT) for detecting and quantifying E.coli bacteria.

Results

Table 1: Demographic, sanitation, and intestinal health characteristics of study participants

Variable	n(%) or x̄ ± SD
Sex of participant child	
Male	190 (49.35%)
Female	195 (50.65%)
Age (months)	14.83 ± 1.06
Caregiver years of education	5.91 ± 2.99
Female headed household	16 (4.16%)
Number of family members	5.68 ± 2.43
Stunted (6 months)	86 (22.69%)
Wasted (6 months)	12 (3.14%)
Floor type	
Dirt	334 (86.75%)
Bricks/stone/cement	51 (13.25%)
Toilet type	
None/bush	2 (0.52%)
Unimproved pit latrine	368 (95.58%)
Improved pit latrine	9 (2.34%)
Community owned toilet	6 (1.56%)
Running water	12 (3.12%)
Water risk category	
Safe	165 (43.77%)
Intermediate risk	51 (13.53%)
High risk	46 (12.20%)
Unsafe	115 (30.50%)
L:M ratio	0.35 ± 0.34
Percent lactulose recovered	0.35 ± 0.65
Percent mannitol recovered	5.34 ± 3.50

- Of the 385 children, 49.35% were male and 50.65% were female, and the average age was 14.8 months. At 6 months of age, 22.69% of the children were stunted and 3.14% were wasted.
- Generally, environmental conditions were fairly ubiquitous across households. The majority of households had dirt floors (86.75%), no running water (96.88%), and an unimproved pit latrine (95.58%). Water quality, however, was highly variable, with 43.77% of households having safe water, 13.53% having water with intermediate risk, 12.20% having water with high risk, and 30.50% having unsafe water.
- The average L:M score was 0.35, with 20.26% having no EED (L:M <0.15), 57.40% having moderate EED (0.15 <= L: M <= 0.45), and 22.34% having severe EED (L:M > 0.45). The average percent lactulose and percent mannitol recovered were 0.35% and 5.34% respectively.

Table 2: Association of sanitation characteristics and ratio of lactulose to mannitol (L:M) excretion

Characteristic	β Coefficient [95% Conf. Interval]	P>|t|
Female	0.046 [-0.024, 0.115]	0.197
Safe water	-0.088 [-0.159, -0.017]	0.016
Amount of water (jerrycans) used daily by household	-0.033 [-0.060, -0.005]	0.020
Caretaker handwashing after toilet use	-0.069 [-0.141, 0.004]	0.063
Goats and/or sheep can enter household	0.126 [0.006, 0.246]	0.039

Overall model: R-squared=0.056, F-statistic=4.37, p=0.0007

- Associations between environmental characteristics and L:M scores were ascertained using linear regression modeling controlling for the sex of the child.
- Children from households with safe drinking water and where water was used in greater quantity had significantly better L:M scores (P<0.050). Where the caretaker reported washing his/her hands after toilet use, children had nearly significantly better L:M scores (p=0.063).
- In households where goats and sheep were allowed to roam inside the dwelling, children had significantly worse L:M scores (P<0.050)

Conclusions

- The results of this study add to the growing body of literature regarding EED in young children. Like similar studies from other developing countries, EED, as measured using the L:M test, is highly prevalent among young children in Southwestern Uganda.
- Furthermore, the results of this study support previous findings that EED is associated with exposure to unsanitary environmental conditions at the household level, specifically water quality and quantity, caretaker handwashing behavior, and contact with animals.

Acknowledgements

Funding source: AID-OAA-L-1-00006. Support for this research was provided by the Feed the Future Innovation Lab for Nutrition, which is funded by the United States Agency for International Development. The opinions expressed herein are solely those of the authors. The authors would like to express special gratitude to the Nutrition Innovation Lab team, Uganda Birth Cohort team, and the study participants.

References

1. Crane, RJ, Jones, KDJ, Berkley, JA. Environmental enteric dysfunction: an overview. Food Nutr. Bull. 2015;36, S76–87 2. Lunn, PG, Northrop-Clewes, CA, Downes, RM. Intestinal permeability, mucosal injury, and growth faltering in Gambian infants. Lancet. 1991;338(8772):907-910 3. Campbell, DI, Elia, M, Lunn, PG. Growth faltering in rural Gambian infants is associated with impaired small intestinal barrier function, leading to endotoxemia and systemic inflammation. J Nutr. 2003; 3133:1332–1338 4. Lin, A, Arnold, BF, Afreen, S, et al. Household environmental conditions are associated with enteropathy and impaired growth in rural Bangladesh. Am J Trop Med Hyg. 2013;89(1):130-137 5. George, CM, Oldja, L, Biswas, S, et al. Geophagy is associated with environmental enteropathy and stunting in children in rural Bangladesh. Am J Trop Med Hyg. 2015;92:1117-1124 6. George CM, Oldja L, Biswas SK, et al. Fecal markers of environmental enteropathy are associated with animal exposure and caregiver hygiene in Bangladesh. Am J Trop Med Hyg. 2015;93(2):269-275