Assessing the relationship between household water quality and environmental enteric dysfunction (EED) in young children living in southwestern Uganda

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Background and Objectives

- Environmental enteric dysfunction (EED) is a subclinical disorder of the small intestine, characterized by altered gut morphology, reduced absorptive capacity, and impaired barrier function.[1]
- EED is highly prevalent, perhaps ubiquitous, in children living in LMICs and is significant mainly due to its association with poor growth outcomes, especially stunting.[23]
- Although EED is hypothesized to be caused by exposure to enteropathogens transmitted via fecal/oral contact[4], specific WASH-related risk factors remain speculative and in need of further study.
- The primary objective of this study was to assess the relationship between household water quality and EED in young children living in southwestern Uganda.

Methods

- This was a cross-sectional, observational sub-study under the Uganda Birth Cohort study conducted by USAID's Innovation Lab for Nutrition based at Tufts University.
- 385 children between 12 and 16 months, from seven sub-counties in southwestern Uganda were enrolled in the study.
- The Uganda Birth Cohort study's 6-month visit provided data on both water quality and study covariates. Water quality was assessed using the Aquagenx Compartment Bag Tests (CBT), a portable test kit designed to detect and quantify *E.coli* bacteria.
- A lactulose: mannitol (L:M) dual sugar test was performed to assess EED. Each child consumed 20 ml. of solution containing 5 grams of lactulose and 1 gram of mannitol. All urine was collected for a minimum of four hours, and 1.5 ml. aliquots were stored at a minimum of -20°C prior to analysis.
- Levels of the two sugars were analyzed using validated HPLC methods at Baylor College of Medicine.
- Regression analysis with appropriate controls was used to determine the association between household water quality and L:M test results.
- The study was approved by the Tufts Health Sciences IRB in Boston, MA, USA; Makerere University REC in Kampala, Uganda; and the Uganda National Council for Science and Technology in Kampala, Uganda.

Results

Table 1: Characteristics of participant children and their households

Female, n (%)	195 (50.7)
Age, months	14. 8 ± 1.1[1]
Anthropometry at 6 months of age	
Length-for-age z score	-0.98 ± 1.51
Weight-for-length z score	0.63 ± 1.41
Weight-for-age z score	-0.25 ± 1.19
Midupper arm circumference, cm	14.1 ± 1.4
Head circumference, cm	43.2 ±1.8
Individuals in household	5.7 ± 2.4
Female household head, n (%)	16 (4.2)
Caregiver age	26.3 ± 6.3
Caregiver education years	5.9 ±3.0
Earth floor, n (%)	334 (86.8)
Electricity, grid or solar, n (%)	61 (15.8)
Wood as fuel for cooking, n (%)	368 (95.6)
Unimproved pit latrine, n (%)	368 (95.6)
Water quantity, jerrycans/ day	2.4 ± 1.3
Boil water, n (%)	274 (71.2)
Main water source, n (%)	
Piped water	8 (2.1)
Public tap	46 (12.0)
Tube well or borehole	61 (15.8)
Protected well or spring	85 (22.1)
Unprotected well or spring	110 (28.6)
Rain water	16 (4.2)
Surface water	56 (14.6)
Other	3 (0.8)
Water quality, n (%)	
Safe	165 (43.8)
Intermediate risk	51 (13.5)
High risk	46 (12.2)
Unsafe	115 (30.5)

- Of the 385 children, 49.4% were male and 50.7% were female, and the average age was 14.8 months at the time of the L:M test.
- Caretakers were ≈26 years of age and had ≈6 complete years of formal education. Households were nearly all male-headed and had ≈6 members. Household characteristics were fairly ubiquitous; almost all had an earth floor, no electricity, and an unimproved pit latrine.
- 43.8% of households had "safe" water, 13.5% had water deemed "intermediate risk", 12.2% had water deemed "high risk", and 30.5% had "unsafe" water.

Table 2: EED results by water quality risk

	All	Safe water	Not safe
L:M ratio	0.35 ± 0.34	0.30 ± 0.24	0.40 ± 0.41
Ln L:M ratio	-1.31 ± 0.72	-1.44 ±0.69	-1.19 ± 0.72
% Exc Lact	0.35 ± 0.65	0.27 ± 0.22	0.41 ± 0.85
% Exc Man	5.34 ± 3.50	5.14 ± 3.59	5.44 ± 3.45
LMER	0.07 ± 0.07	0.06 ± 0.05	0.08 ± 0.08
EED level			
Normal	78 (20.3)	39 (23.6)	36 (17.0)
Moderate	221 (57.4)	99 (60.0)	117 (55.2)
Severe	86 (22.3)	27 (16.4)	59 (27.8)

- 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 3: Relationship between water quality and L:M test results

Outcome	Age Adjusted	Fully Adjusted[1]
L:M ratio	-0.10 (-0.17, -0.30)*	-0.10 (-0.17, -0.30)*
Ln L:M ratio	-0.25 (-0.39, -0.10)*	-0.24 (-0.39, -0.09)*
% Exc Lact	-0.15 (-0.28, -0.01)*	-0.15 (-0.29-0.01)*
LMER	-0.02 (-0.03,-0.006)*	-0.02 (-0.03,-0.006)*

1. Fully adjusted model adjusts for sex, age, age squared, sex of household head, caregiver education level, family size, and asset score

* P-value less than 0.05

- Compared with children from households with unsafe water, children from households with safe water had a significantly lower L:M ratio, signifying better overall intestinal health.
- Furthermore, children from households with safe water had lower recovery of lactulose, signifying better mucosal integrity.

Photo 1: Aquagenx Compartment Bag Test

Conclusions

- This study supports the hypothesis that EED is caused by living in conditions of poor WASH. Poor water quality, in particular, could be a significant cause of EED in young children but further exploration is necessary.
- Water source is a poor proxy indicator for water quality. Testing for the presence of pathogens is a preferred method.

Keywords

Environmental enteric dysfunction (EED), intestinal permeability, L:M test, water and sanitation (WASH), water quality

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