



Environmental Enteric Dysfunction as a Potential Modifier of the Effect of Specialized Nutritious Foods in the Treatment of Moderate Acute Malnutrition in Sierra Leone

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OBJECTIVE

- To understand how specialized nutritious foods (SNFs) enable a child to recover from moderate acute malnutrition (MAM), the role of conditions such as environmental enteric dysfunction (EED), impairment of the small intestine, needs to be studied.
- The objective of this study was to examine whether EED at enrollment modifies the effect of SNFs on graduation from a MAM treatment program.

METHODS

- Sierra Leonean children 6-59 months with MAM (mid-upper arm circumference $\geq 11.5\text{cm}$ & $< 12.5\text{cm}$) and no clinical complications (e.g. edema) were supplemented with one of four SNFs in isocaloric rations of $\sim 550\text{kcal/day}$.
- The SNFs were:



- EED was assessed at enrollment using the lactulose:mannitol (L:M) test on a sub-set of participants (Table 1).
- Logistic regression was used to test for effect modification by EED (Table 2).
 - Outcome: Graduation (MUAC $\geq 12.5\text{cm}$) from the MAM treatment program within 12 weeks (binary).
 - Exposure: SNFs (categorical).
 - Effect modifiers: % lactulose excreted (%L), % mannitol excreted (%M), lactulose:mannitol excretion ratio (LMER), and lactulose:mannitol ratio (L:M Ratio) in separate models (continuous).
- Chi-square test was used to examine difference in percentage graduated from the MAM treatment program by presence of EED at enrollment defined as $\%L \geq 0.2$ (Figure 1). Cut-offs for other L:M test variables are not as well established.

RESULTS

Table 1. Characteristics of EED sub-study participants

| | All | CSWB w/oil | SC+A | CSB+ w/ oil | RUSF | P-value |
|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------|
| n | 390 | 56 | 115 | 96 | 123 | |
| Enrollment | | | | | | |
| Age (months) | 14.67 \pm 9.19 | 13.45 \pm 9.32 | 14.31 \pm 9.52 | 14.34 \pm 8.15 | 15.81 \pm 9.55 | 0.372 |
| Female | 220(57%) | 33(60%) | 71(62%) | 44(46%) | 72(59%) | 0.123 |
| Transferred from SAM | 91(24%) | 12(22%) | 26(23%) | 32(34%) | 21(17%) | 0.037 |
| Anthropometry | | | | | | |
| MUAC | 11.97 \pm 0.27 | 12.02 \pm 0.28 | 11.95 \pm 0.26 | 11.96 \pm 0.27 | 11.99 \pm 0.27 | 0.384 |
| LAZ | -2.83 \pm 1.38 | -2.76 \pm 1.45 | -2.72 \pm 1.28 | -2.92 \pm 1.42 | -2.9 \pm 1.42 | 0.670 |
| WLZ | -1.88 \pm 0.74 | -1.73 \pm 0.8 | -1.82 \pm 0.73 | -1.92 \pm 0.75 | -1.98 \pm 0.7 | 0.124 |
| WAZ | -2.96 \pm 0.87 | -2.88 \pm 0.85 | -2.85 \pm 0.83 | -3 \pm 0.91 | -3.05 \pm 0.86 | 0.291 |
| EED | | | | | | |
| %L | 0.34(0.21 - 0.62) | 0.37(0.2 - 0.6) | 0.33(0.23 - 0.7) | 0.31(0.2 - 0.58) | 0.34(0.19 - 0.59) | 0.185 |
| %L ≥ 0.2 | 301(77%) | 43(77%) | 95(83%) | 72(75%) | 91(74%) | 0.407 |
| %M | 3.87(2.42 - 5.65) | 3.61(2.32 - 5.75) | 3.85(2.41 - 5.62) | 3.53(2.31 - 5.39) | 4.23(2.53 - 5.91) | 0.185 |
| LMER | 0.1(0.06 - 0.15) | 0.1(0.07 - 0.14) | 0.1(0.06 - 0.16) | 0.1(0.07 - 0.15) | 0.09(0.06 - 0.12) | 0.760 |
| LM ratio | 0.48(0.32 - 0.73) | 0.51(0.36 - 0.69) | 0.5(0.31 - 0.79) | 0.49(0.33 - 0.77) | 0.43(0.31 - 0.62) | 0.630 |
| Outcome | | | | | | |
| Graduated | 254(66%) | 33(60%) | 70(61%) | 61(64%) | 90(73%) | 0.165 |

Cells represent Mean \pm SD or n(%) or Median(inter quartile range).
P-value for difference between SNFs by linear regression for continuous variables, chi-square test for categorical variables, and median test for EED variables.
Abbreviations: SAM, severe acute malnutrition; MUAC, mid-upper arm circumference; LAZ, length-for-age z score; WLZ, weight-for-length z score; WAZ, weight-for-age z score; EED, environmental enteric dysfunction; %L, percent lactulose, %M, percent mannitol, LMER, lactulose mannitol excretion ratio, LM, lactulose mannitol.

Table 2. No interaction between EED (as defined by %L, %M, LMER, and LM Ratio), and SNFs in predicting recovery from MAM, n=387

| | %L β (95% CI) | %M β (95% CI) | LMER β (95% CI) | LM Ratio β (95% CI) |
|-------------------------------|------------------------|------------------------|--------------------------|------------------------------|
| SNFs | | | | |
| CSB+ w/ oil | Reference | Reference | Reference | Reference |
| CSWB w/ oil | -1.17(-2.41, 0.07) | -1.37(-2.93, 0.19) | -0.72(-2.38, 0.93) | -0.72(-2.38, 0.93) |
| SC+A | -0.66(-1.63, 0.31) | -0.11(-1.23, 1.01) | -1.49(-2.67, -0.32) | -1.49(-2.67, -0.32) |
| RUSF | -0.12(-1.10, 0.86) | 0.18(-0.99, 1.35) | -0.48(-1.68, 0.73) | -0.48(-1.68, 0.73) |
| EED ¹ | -0.93(-2.27, 0.40) | 0.01(-0.17, 0.20) | -8.24(-15.47, -1.02) | -1.65(-3.09, -0.20) |
| SNFs * EED¹ | | | | |
| CSB+ w/ oil | Reference | Reference | Reference | Reference |
| CSWB w/ oil | 2.13(-0.26, 4.52) | 0.29(-0.08, 0.65) | 3.42(-9.69, 16.53) | 0.68(-1.94, 3.31) |
| SC+A | 1.11(-0.55, 2.76) | -0.02(-0.25, 0.22) | 11.07(2.80, 19.34) | 2.21(0.56, 3.87) |
| RUSF | 0.97(-0.73, 2.66) | 0.03(-0.21, 0.26) | 6.41(-2.32, 15.14) | 1.28(-0.46, 3.03) |
| P _{interaction} | 0.331 | 0.384 | 0.051 | 0.051 |
| R ² | 0.112 | 0.115 | 0.122 | 0.122 |

¹Takes the value %L, %M, LMER and LM Ratio in separate models.
Logistic regression models adjusted for child age, gender and previous severe acute malnutrition status.
One highly influential observation excluded from models with LMER and LM Ratio.

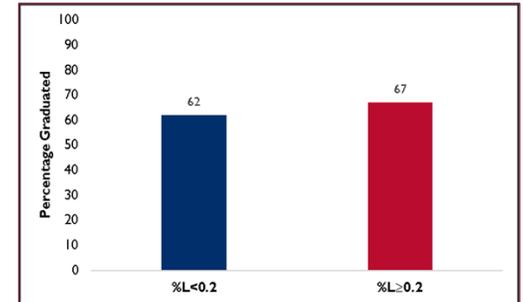


Figure 1. Percentage graduated from the MAM treatment program by presence of EED at enrollment defined as $\%L \geq 0.2$. Chi-square test p-value = 0.407.

CONCLUSIONS

- Prevalence of EED ($\%L \geq 0.2$) at enrollment was high (77%) among MAM children in this study.
- EED (L:M test) at enrollment did not affect graduation from the MAM treatment program within 12 weeks.
- EED (L:M test) at enrollment did not modify the effect of any of the SNFs in regard to graduation from the MAM treatment program within 12 weeks.
- These findings suggest that EED may not affect graduation from the program, or that EED changes over the course of treatment.



ACKNOWLEDGEMENTS

- This work was made possible through support provided by the Office of Food For Peace, Bureau for Democracy, Conflict, and Humanitarian Assistance, U.S. Agency for International Development, under the terms of Contract No. AID-OAA-C-16-00020. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.
- In the field, samples were stored in liquid nitrogen supplied by the Department of Biological Sciences, Njala University, Sierra Leone. Samples were stored at the University of Makeni Infectious Disease Research Laboratory, Sierra Leone. Concentration of the sugars was analyzed at Baylor College of Medicine, Texas, USA.