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Lack of Association of Household Income and Acute Gastroenteritis Disease Severity in Young Children: A Cohort Study

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Contributors Statement

Thomas Chun conceptualized and designed the study, coordinated and supervised data collection, reviewed and revised the manuscript, approved the final manuscript as submitted, and agrees to be accountable for all aspects of the work.

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Stephen B. Freedman conceptualized and designed the study, designed the data collection instruments, reviewed and revised the manuscript, approved the final manuscript as submitted, and agrees to be accountable for all aspects of the work.

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Abstract

Objective: To determine if low household income is associated with disease severity following emergency department (ED) discharge in children with acute gastroenteritis (AGE).

Methods: We conducted a secondary analysis employing data collected in ten US-based tertiary-care, pediatric EDs between 2014 and 2017. Participants were aged 3–48 months and presented for care due to AGE. Income status was defined based on 1)home ZIP Code median annual home income and 2)percentage of home ZIP Code households below the poverty threshold. The primary outcome was moderate-to-severe AGE, defined by a post-ED visit Modified Vesikari Scale (MVS) score ≥9. Secondary outcomes included in-person revisits, revisits with intravenous rehydration, hospitalization, and etiologic pathogens.

Results: 943 (97%) participants with a median age of 17 months (IQR 10, 28) completed follow-up. Post-ED visit MVS scores were lower for the lowest household income group (adjusted: −0.59; 95%CI: −1.09, −0.08). Odds of experiencing an MVS score ≥9 did not differ between groups (adjusted OR: 0.91; 95%CI: 0.53, 1.56). No difference in the post-ED visit MVS score or the proportion of participants with scores ≥9 were observed using the national poverty threshold definition. For both income definitions, there were no differences in terms of revisits following discharge, hospitalizations and intravenous rehydration. Bacterial enteropathogens were more commonly identified in the lowest socio-economic group using both definitions.

Conclusions: Lower household income was not associated with increased disease severity or resource use. Economic disparities do not appear to result in differences in the disease course of children with AGE seeking ED care.

Keywords

Gastroenteritis; Emergency Service; Hospital; Income; Poverty; Child

Introduction

While mortality from acute gastroenteritis (AGE) is rare in high-income countries, it remains a leading cause of death among children worldwide and one of the most common causes of health care provider visits in US children <5 years of age.(1) While socio-economic status (SES) is a risk factor for higher illness severity and mortality for numerous infectious diseases,(2, 3) the relationship between SES and AGE severity is unknown. Studies have focused on disease incidence and have reached mixed conclusions, with elevated risks of gastrointestinal infections reported at both ends of the SES spectrum;(4–7) others have reported that risk varies by pathogen.(7–9) Ecologic studies have been limited to individual countries [e.g. the United Kingdom,(4, 10) Denmark,(6) Australia(5)], employed various AGE definitions, used indirect severity measures [e.g. hospitalization,(4, 6, 10) self-reported food poisoning(5)], and only two focused on children.(4, 6) Although a systematic review of 16 studies from 10 high-income countries found no uniform effect of SES on foodborne illness incidence, the authors postulated that reporting bias may explain this finding.(8) As included studies analyzed laboratory confirmed cases, and not all illnesses have laboratory testing performed, those causing milder symptoms may be under-reported and SES groups have varying rates and patterns of healthcare utilization.(11)

To investigate the association between SES and AGE disease severity, outcomes, and healthcare resource utilization after an AGE-associated ED visit, we analyzed a dataset of children with AGE prospectively enrolled in 10 geographically diverse EDs located in the United States. Unfortunately, SES is a multi-dimensional construct with many possible indicators that are not routinely collected. However, use of area-based SES indicators obtained from address data linked to geocoded census information has been identified as a suitable surrogate.(12) As such, we employed ZIP codes to classify household income status and hypothesized that following discharge, those with lower household income would be more likely to experience moderate-to-severe AGE disease and would utilize more healthcare resources in the 7 days following an index ED visit.

Methods

Design and Settings:

This was a planned secondary analysis of the PECARN (Pediatric Emergency Care Applied Research Network) Probiotics study, a randomized controlled trial of children with AGE administered *Lactobacillus rhamnosus* GG (LGG) or placebo.(13, 14) The ethics committees of the participating institutions located in Albuquerque (New Mexico), Ann Arbor (Michigan), Chicago (Illinois) Cincinnati (Ohio), New York (New York), Providence (Rhode Island), Sacramento (California), Salt Lake City (Utah), St. Louis (Missouri), and Washington (District of Columbia), approved the study. Caregivers of all participants provided written informed consent.

Study Population:

Between July 2014 and June 2017, 971 children aged 3–48 months diagnosed in the ED as having AGE, had ≥3 watery stools in the preceding 24 hours, and AGE symptoms for <7 days, were enrolled. Exclusion criteria included: signs of critical illness or acute abdomen, chronic gastrointestinal problems, an indwelling catheter or immunosuppression (patient and family members), probiotic use within the last 2 months, and allergy to study medication or antibiotics which might be needed if LGG resulted in a disseminated infection. Participant recruitment varied by site but generally attempted to recruit children 7 days/week between 8 AM and 12 PM.

ED Visit/Hospital Stay:

Participants were identified, screened and approached in the ED by study research coordinators. After informed consent was obtained, participants were randomized to twice daily LGG or an identical placebo for 5 days. At discharge, study coordinators provided parents with information on study drug administration, oral rehydration therapy, when and how to seek further medical care, and study procedures to complete at home.

Follow-Up:

Parents were provided a diary to record their child's symptoms. The research team contacted the family daily to collect outcome data until symptoms resolved or a minimum of five days had elapsed since enrollment, whichever was longer. Caregivers were contacted again at day 14. Follow-up surveys were performed by phone by a central study coordinator utilizing a standardized script or electronically (i.e. e-mail) to enable the identification of medical care provided outside the enrolling facilities. To verify data regarding revisits and subsequent medical care, chart reviews of participants' electronic health record were performed.

Enteropathogen Identification:

Rectal swabs (FecalSwab, Copan Diagnostics), stool specimens, or both were obtained during the enrollment visit. Specimens underwent multiplex nucleic acid panel testing to detect the presence of 15 enteric viruses, bacteria, and parasites (Luminex xTAG Gastrointestinal Pathogen Panel).

Outcomes:

The primary outcome was post-ED visit AGE symptom severity quantified by the Modified Vesikari Scale (MVS) score. The MVS score is a validated system (maximum score: 20) which estimates the severity of an AGE episode(15, 16) and includes 7 items: diarrhea and vomiting duration and maximal frequency in a 24-hour period, maximal temperature, unscheduled in-person healthcare provider visits and treatments provided. Moderate-to-severe disease is defined as a post-enrollment visit MVS score ≥9.(15) Data to calculate the score were collected through study follow-up procedures. The post-enrollment MVS score was calculated once the AGE symptoms have resolved. Secondary outcomes included ED revisits, revisits with intravenous rehydration, and hospitalization during the 7-day interval following the enrollment ED visit due to diarrhea, vomiting,(17) abdominal pain or fever. Lastly, we sought to determine if there was a difference in etiologic pathogens based on household income.

Data:

Demographic variables included in our analyses were age, sex, race/ethnicity, and household income. The latter was assigned based on information about the participant's home ZIP Code according to the United States Census Bureau, 2012–2016 American Community Survey 5-Year Estimates.(18) As participant level SES determinants were not explicitly collected as part of the trial, we post-hoc classified and analyzed household income utilizing two methods. The approaches selected are recommended for monitoring disparities within healthcare systems based on evidence that area-based SES indicators detect health outcome differences.(12) First, we determined low household income status based on the median annual home income in the participant's home ZIP Code compared to the 2016 poverty threshold for 2 adults plus 2 children (annual home income below $24,339).(19) Second, we stratified participant ZIP Codes into quartiles based on the percentage of the participant's home ZIP Code below poverty and compared the lowest quartile to the other three.(12, 20) Household income was coded as "missing" if the estimated margin of error from the American Community Survey was greater than the estimate, which occurs when there are small sample sizes within a ZIP Code, rendering the data unreliable. These participants were retained through use of multiple imputation.

Statistical Analysis:

We compared demographic characteristics and clinical outcomes between household income categories using medians, interquartile ranges, and Wilcoxon rank-sum tests for continuous characteristics, and frequencies, percentages, and likelihood ratio tests for categorical characteristics. It was assumed, that at the time of ED discharge, children with AGE had similar hydration statuses (i.e. well hydrated). *A priori*, we analyzed the post-ED visit MVS score as binary (≥9 vs. <9) and continuous dependent variables. We utilized multivariable mixed logistic regression to estimate the odds ratio of experiencing a MVS score ≥9 for participants in a low household income ZIP Code versus not, while controlling for other variables. In addition, a multivariable mixed linear regression model was fitted to estimate the difference in MVS scores for participants in a low household income ZIP Code versus not, while controlling for other variables. Both models were repeated using both household

income definitions. Models were adjusted for the enrolling ED using random intercepts, and estimated the following effects: baseline MVS score (i.e. symptom reported from illness onset until the index ED visit), sex, race/ethnicity, prior healthcare provider visit, history of rotavirus vaccine, Clinical Dehydration Scale score,(21) infectious agent (i.e. isolated bacteria, isolated virus, parasite, virus/bacteria co-detection, or not tested versus negative), and number of individuals living in the household (including the participant, capped at 12 persons). Although the clinical trial identified no effects attributable to the intervention,(13) treatment received was included in the models. Covariate collinearity was assessed using variance inflation factors and area under the curve (AUC) to quantify the association between household income and collinear covariates. Goodness-of-fit tests and residual diagnostics were inspected. We estimated the AUC for the mixed logistic regression model.

We similarly estimated logistic regression models for the secondary outcomes of AGE-associated ED revisits, subsequent intravenous rehydration, and hospitalization during the 7-day interval following enrollment. The same covariates included in the primary models were incorporated into secondary outcome analysis models with the exception of infectious agent, race/ethnicity (from the hospitalization and intravenous rehydration models given the limited number of events) and random intercepts, which were excluded to attain model convergence.

All patients who provided follow-up data are included. Multiple imputation, performed with IVEware software utilizing chained regression models (University of Michigan, Ann Arbor, MI), was employed to retain patients with incomplete follow-up. Imputation results were combined using standard methods.(22) At least one outcome or covariate was imputed for 351 (37%) participants, including the MVS outcome score for 40 (4%) and household income for 14 (1%).

Analyses were performed using SAS/STAT software, Version 9.4 (SAS Institute Inc., Cary, NC, USA). A significance level of 0.05 was used for all statistical tests; no adjustments were made for multiple tests.

Results

971 study participants were recruited into the trial of whom 943 (97%) provided follow-up information and are included in this analysis; Figure 1. Median age was 17 months (IQR 10, 28), 439 (47%) were female, 349 (37%) identified as Hispanic, 321 (34%) as black non-Hispanic, 188 (20%) as white non-Hispanic, and 85 (9%) as other, non-Hispanic; Table 1. Although the proportion of low household income participants varied by ZIP Code classification method, demographic characteristics did not differ between low and not-low household income groups between approaches; Table 1. By both definitions, a disproportionate number of black Non-Hispanic children were classified as having low household income.

Primary Outcomes:

Using the household income quartiles definition (Table 2), the lowest quartile had a lower post-ED visit MVS score (i.e. less severe disease) compared to the higher 3 quartiles (i.e. not low household income group) [median (IQR): 3 (2, 5) vs. 4 (2, 6), respectively; P<0.001]. Unadjusted and adjusted differences in mean MVS scores were lower in the low household income group (Table 3: unadjusted difference: −0.60; 95%CI: −1.13, −0.07; adjusted difference: −0.45; 95%CI: −0.97, 0.06). The odds of experiencing moderate-severe AGE (i.e. MVS score ≥9) did not differ between groups (Supplemental Table 1: unadjusted OR: 0.91; 95%CI: 0.54, 1.52; adjusted OR: 1.10; 95%CI: 0.63, 1.93). No difference in either the post-ED visit MVS score or in the proportion of participants with scores ≥9 were observed using the national poverty threshold household income definition before or after adjustment.

In both multivariable models, factors predictive of a higher post-ED visit MVS score as a continuous variable (Table 3) were white/Non-Hispanic (relative to Black/Non-Hispanic and Hispanic), higher baseline MVS score, Clinical Dehydration Scale scores, and the infectious agent (virus/bacteria co-detection versus negative). Factors associated with the development of moderate-severe AGE post-ED visit (Supplemental Table 1) with the MVS considered as a categorical variable (i.e. <9 vs. ≥9), were fewer people in the household, higher baseline MVS score and being white/Non-Hispanic (relative to Black/Non-Hispanic and Hispanic).

Secondary Outcomes:

For both definitions, there were no differences between groups (Table 2) in terms of ED revisits following discharge, hospitalizations and intravenous rehydration. However, children classified as low household income using the quartile method were less likely to have an unscheduled primary care provider in-person visit within 7 days of the index ED visit. No association between secondary outcomes and household income was found in either adjusted or unadjusted logistic regression models using either household income definition (Supplemental Tables 2–4). There was a difference in infectious pathogens identified with isolated bacteria being more common in the low household income group when defined by national poverty threshold (11.2% vs. 7.0%; P=0.005) and lowest quartile (13.0% vs. 5.5%; P=0.003); Supplemental Table 5.

Discussion

In this large, diverse sample of children recruited from 10 EDs distributed across the US, we found no evidence associating household income with increased AGE severity following an ED visit. We did find that race/ethnicity – being white/Non-Hispanic, relative to Black and Black/Non-Hispanic – was associated with higher post-ED visit MVS scores as a continuous variables and with development of moderate-severe AGE as a categorical outcome. There were no differences in secondary outcomes of ED revisits with 7 days of discharge, ED revisits associated with intravenous rehydration, or hospitalizations during the 7-day interval following the enrollment ED visit due to diarrhea, vomiting or other ongoing AGE-associated symptoms associated with household income status.

Although we found a 1-point MVS score difference in the unadjusted analysis, in our multivariable model, household income was not independently associated with the MVS score as a continuous variable (Table 3). Moreover, this difference was not observed when the outcome measure was dichotomized into mild vs. moderate-severe AGE with either household income definition. A potential explanation for the lack of association between low household income and disease severity is that since the MVS score incorporates follow-up health care seeking behavior, individuals with higher household income may have increased access to care. Despite the latter group having more frequent unscheduled primary care provider in-person visits, re-analysis of the score with follow-up visits and treatments provided included in the multivariable model, no association was detected. Another possible explanation is that families with lower household income might seek care in the ED for less severe illness, perhaps due to more limited access to a primary care provider. However, at the time of the index ED visit (Table 1) clinical disease severity did not vary based on household income and such variables were included in our multivariable models.

When the MVS score was analyzed as a continuous variable, the baseline MVS score, index ED visit Clinical Dehydration Scale score, and identification of an infectious agent, were all associated with greater symptom severity following the index ED visit. As a categorical variable, significant predictors included the number of individuals living in the household and the baseline MVS score. These associations likely reflect index ED visit increased illness severity and increased pathogenicity [i.e. infectious agent(9)]. Perhaps more importantly was the association, in both MVS score outcome models using both definitions of household income, between white/Non-Hispanic race/ethnicity and higher disease severity following the index ED visit. Although inequalities in health care delivery based on race/ethnicity are well documented,(23, 24) there is limited evidence associating race/ethnicity and disease severity in this context. Previous research has demonstrated that Black and Hispanic children are less likely than white children to have ED visit acuity classified as immediate/emergent and to be admitted to the hospital following the visit.(25) As our findings are unlikely to represent differential biological responses to an infectious agent, they more likely support the suggestion that Black families are more likely to bring their children to the ED for non-acute illnesses.(26, 27)

A strength of this study is use of the quantitative MVS score for the primary outcomes. The score, which measures overall AGE severity, has been validated for use in pediatric EDs,(15, 16) has good reliability and construct validity and captures important healthcare resource utilization outcomes. Moreover, our analysis, is based on prospectively collected, patient-level outcome data, thereby overcoming barriers inherent in large database analyses, and only 3% of study participants were lost to follow-up.

Our use of aggregated ZIP Code data to derive household income values may have exaggerated the effects of divergence in income estimates that truly exists at the micro-level.(28) However, this approach is considered to be the most robust available(12) and correlates strongly with self-reported educational attainment,(12) another widely used and well-validated SES indicator.(29) Nonetheless, using regional data to imply patient-level SES, may have misclassified participants and their families as the accuracy of the community-level data for identifying patients with social risks is suboptimal.(30) Our

classification of household income using the quartile approach artificially forced individuals that may not truly have a low household income into the lowest quartile based on the composition of our population. This seems to have increased the proportion of black and Hispanic children in the low household income grouping.

An alternative analytic approach, which was considered, is the use of the Area Deprivation Index (ADI), which uses 17 US Census indicators encompassing poverty, education, housing, and employment, to characterize census based regions.(31, 32) Unfortunately, the ADI is available at the 9-digit Zip code level, not at a 5-digit Zip code level, which reflects the limitations of the data available. As the ADI is not endorsed for use at the 5-digit Zip code level, such an approach was not possible.

While most studies of SES and AGE in children have focused on disease incidence, our analysis is unique in its focus on severity. In a prospective study of AGE in the Netherlands, higher rates of AGE was associated with higher SES.(33) National studies of hospitalizations rates for AGE in Denmark and England found the opposite effect, associating increased hospitalization rates with lower SES.(4, 6, 10) This study adds important, new information about the relationship between AGE outcomes and household income in a large, socio-economically diverse, high-income country. Consistent with previous work, which found that ≥10 vomiting episodes in the preceding 24 hours and a higher discharge heart rate are associated with ED revisits,(34) we found that baseline severity of illness was predictive of more severe AGE outcomes.

Previous studies have associated severe disease with *Campylobacter* spp., *Salmonella* spp., and *Escherichia coli* infections.(8, 9) Although illness from the three aforementioned organisms has been associated with high SES, *Listeria* infection is associated with lower SES.(8) In this study, household income defined by quartiles, and the presence of an identified pathogen (compared with no pathogen identified on testing), were associated with higher MVS scores. A systematic review found a pattern towards higher risk of infection by foodborne and person-to-person infections in disadvantaged populations.(7) In our study, bacterial pathogens were more commonly responsible for AGE disease among lower household income groups. However, we cannot exclude the possibility that households with lower incomes may have greater contacts with international travelers who are at elevated risk of harboring bacterial enteropathogens, notably, *Salmonella*.(35) However, although the Luminex platform we employed has high diagnostic accuracy and specificity, (36) it is possible that some bacterial [e.g. *Salmonella*(37)] and parasitic detections were false positives.

Neither repeat ED visits, intravenous rehydration, nor hospitalizations within 7 days of ED discharge were associated with either household income classification. Other studies have reported that low-SES patients are twice as likely as high-SES patients to require urgent ED visits,(38, 39) four times more likely to require hospitalization,(40) and more likely to return to the hospital after discharge.(41, 42) These conflicting findings may reflect the fact that household income is not correlated with illness severity when children are discharged from one of our participating EDs and the natural history of illness, subsequent clinical course, and resource use does not differ based on household income.

Although, based on previously reported SES data, our study population reflects that of the participating EDs,(43) it may not reflect the broader community, as low SES, lower educational achievements, and having medical insurance are associated with seeking medical care.(44, 45) It is plausible that lower household income children in our study differ from the non-low household income children seeking care at the same medical facilities in terms of illness severity (i.e. lower household income children with mild gastroenteritis symptoms may be more likely to seek care compared with non-lower household income counterparts) which may have biased our findings. Study EDs were primarily large, tertiary care, academic referral centers which may not permit the extrapolation of our findings to rural communities where there is a growing disparity in health outcomes that is largely explained by measures of poverty and income.(46) In addition, Black and Hispanic children are over-represented in our study relative to the general U.S. population. Similarly, study participants may be different than those who declined to participate and from the general US population leading to selection bias. Lastly, although an alternative approach to assessing SES status would be to use payer status (i.e. Medicaid status) as a more direct method to determine that a patient has socio-economic needs beyond extrapolating based on where they live. Unfortunately, such data, and other potentially relevant covariates such as housing, education and employment, were not collected and could not be included in the models.

CONCLUSION

We found no evidence that lower household income was associated with increased AGE severity following an ED visit. There was no association when severity was analyzed as a dichotomous measure or when other outcome measures were considered. We did find that being white/Non-Hispanic, relative to Black and Black/Non-Hispanic was associated with higher post-ED visit MVS scores as a continuous variables and with development of moderate-severe AGE as a categorical outcome. In addition, baseline disease severity and the infectious pathogen were associated with post-ED visit disease severity. Overall, our findings are reassuring regarding the role household income plays in disease severity, with outcomes being more strongly determined by standard clinical factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data Sharing Statement:

Deidentified individual participant data (including data dictionaries) will be made available, in addition to study protocols, the statistical analysis plan, and the informed consent form. The data will be made available upon publication to researchers who provide a methodologically sound proposal for use in achieving the goals of the approved proposal. Proposals should be submitted to Stephen.freedman@ahs.ca.

Abbreviations

AGE	Acute Gastroenteritis
AUC	Area Under the Curve
ED	Emergency Department
LGG	*Lactobacillus* GG
MVS	Modified Vesikari Scale
SES	Socio-Economic Status

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What is New

Lower household income is not associated with increased disease severity, emergency department revisits, hospitalizations or intravenous rehydration. Although household income is unlikely to determine the course of pediatric gastroenteritis, bacterial enteropathogens were more commonly identified in the lowest income group.

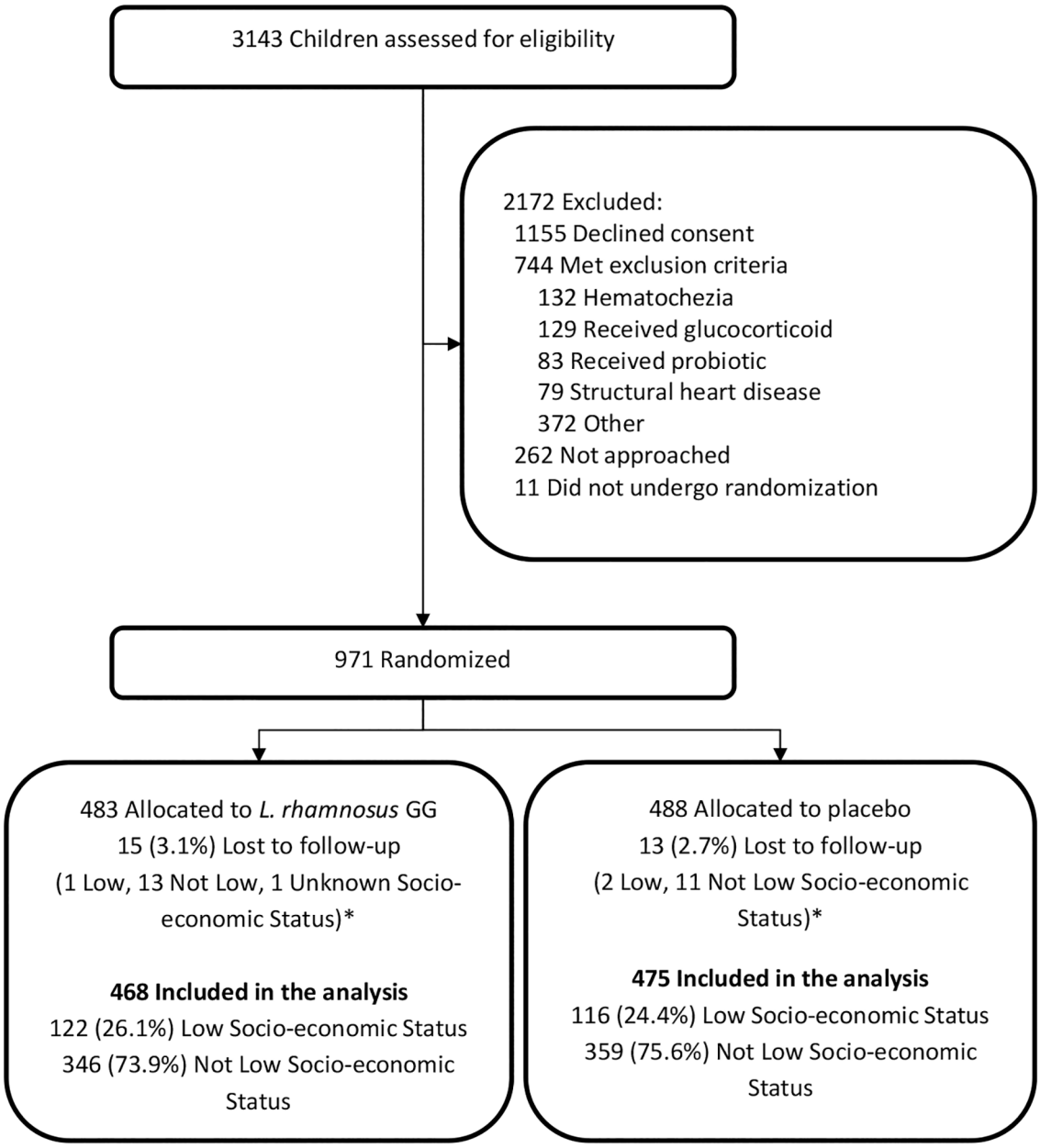

Figure 1.
Study flow diagram.
* Patient's ZIP Code is in the lowest household income quartile based on percent of ZIP Code below poverty.

Table 1.

Characteristics by socio-economic status. Median (25th percentile, 75th percentile) or N (%) shown. *

	Patient's ZIP Code median income is below the national poverty threshold†			Patient's ZIP Code is in the lowest SES quartile based on percent of ZIP Code below poverty‡		
	Low SES (N = 99)	Not Low SES (N = 844)	*P*-value	Low SES (N = 238)	Not Low SES (N = 705)	*P*-value
Age in months, median (IQR)	18.9 (11.0–26.4)	16.8 (10.3–28.1)	0.74	17.9 (10.5–28.9)	16.7 (10.3–27.2)	0.19
Sex N (%)			0.54			0.68
Male	56 (56.4%)	448 (53.1%)		130 (54.6%)	374 (53.1%)	
Female	43 (43.6%)	396 (46.9%)		108 (45.4%)	331 (46.9%)	
Race/Ethnicity N (%)						
White Non-Hispanic	3 (3.0%)	185 (21.9%)		7 (2.9%)	181 (25.7%)	
Hispanic	12 (12.4%)	337 (39.9%)	<0.001	85 (35.8%)	264 (37.4%)	<0.001
Black Non-Hispanic	76 (77.0%)	245 (29.0%)		130 (54.7%)	191 (27.1%)	
Other Non-Hispanic	8 (7.6%)	78 (9.2%)		16 (6.6%)	69 (9.8%)	
Number of People in the Household	5.0 (4.0–5.7)	4.0 (4.0–6.0)	0.41	4.0 (3.0–5.0)	4.0 (4.0–6.0)	0.27
Number of diarrheal episodes in the 24 hours prior to randomization	6.0 (4.0–9.9)	6.0 (4.0–9.0)	0.63	6.0 (4.0–8.0)	6.0 (4.0–9.0)	0.95
Duration of diarrhea prior to randomization (hours)	54.6 (29.9–77.8)	53.1 (29.0–81.9)	0.90	52.7 (27.9–78.0)	53.4 (29.4–81.9)	0.65
Presence of vomiting prior to randomization	72 (72.5%)	646 (76.4%)	0.41	178 (74.7%)	539 (76.5%)	0.58
Number of vomiting episodes in the 24 hours prior to randomization§	3.0 (2.0–5.1)	4.0 (2.0–6.0)	0.36	3.0 (2.0–6.0)	4.0 (2.0–6.0)	0.67
Duration of vomiting prior to randomization (hours) §	37.4 (15.2–72.2)	45.1 (21.0–75.3)	0.41	41.0 (14.7–72.2)	45.3 (22.1–76.4)	0.18
Fever (measured or tactile assessment)	46 (47.1%)	476 (56.4%)	0.08	127 (53.3%)	396 (56.2%)	0.43
Clinical Dehydration Scale Score(27)			0.60			0.02
None (0)	74 (75.5%)	603 (71.4%)		188 (78.8%)	490 (69.5%)	
Mild to Moderate (1–4)	23 (23.4%)	224 (26.5%)		47 (19.8%)	200 (28.3%)	
Severe (5–8)	1 (1.1%)	18 (2.1%)		3 (1.4%)	15 (2.2%)	

SES, Socio-economic Status.

*P-values for characteristics reported as Median (IQR) are from Wilcoxon rank-sum tests; those reported as N (%) are from Likelihood ratio tests. Residential ZIP Code was used to determine socio-economic variables.

†Threshold for ZIP Code Median Income: < $24,339 in 2016 US dollars, the poverty threshold in 2016 for 2 adults/2 children.

‡Threshold for Percent of ZIP Code Below Poverty: > 31.5%, the upper quartile of observed values.

§Among those with vomiting prior to randomization.

Table 2.

Outcomes versus household income status. Unadjusted tests of association shown. Median (25th percentile, 75th percentile) shown unless otherwise noted.

	Patient's ZIP Code median income is below the national poverty threshold			Patient's ZIP Code is in the lowest household income quartile based on percent of ZIP Code below poverty		
	Low Household Income (N = 99)	Not Low Household Income (N = 844)	*P*-value	Low Household Income (N = 238)	Not Low Household Income (N = 705)	*P*-value
Post-Enrollment MVS Score, (21, 22) median (IQR) *	3.0 (2.0–6.0)	4.0 (2.0–6.0)	0.17	3.0 (2.0–5.0)	4.0 (2.0–6.0)	<0.001
Post-Enrollment MVS Score, (21, 22) excluded additional healthcare visits and medical treatment ** median (IQR)	3.0 (2.0–6.0)	3.0 (2.0–5.0)	0.26	3.0 (2.0–5.0)	4.0 (2.0–6.0)	<0.001
Moderate-Severe Acute Gastroenteritis (MVS ≥ 9), N (%)	11 (11.0%)	104 (12.3%)	0.70	26 (10.8%)	89 (12.6%)	0.47
Duration of diarrhea after randomization, median, hrs (IQR)	50.1 (20.9–84.5)	50.4 (22.4–87.8)	0.70	46.4 (15.0–82.5)	53.3 (23.8–88.9)	0.01
Total number of diarrhea episodes, median (IQR)	7.7 (2.0–13.4)	7.0 (3.0–13.0)	0.94	6.0 (2.0–12.3)	7.0 (3.0–13.0)	0.03
Maximum number of diarrhea stools in 24 hrs, median (IQR)	3.0 (2.0–4.0)	3.0 (2.0–5.0)	0.51	3.0 (2.0–4.0)	3.0 (2.0–5.0)	0.01
Duration of vomiting after randomization, median, hrs (IQR)	0.0 (0.0–3.4)	0.0 (0.0–3.8)	0.76	0.0 (0.0–0.0)	0.0 (0.0–5.8)	0.09
Total number of vomiting episodes, median (IQR)	0.0 (0.0–1.0)	0.0 (0.0–1.0)	0.79	0.0 (0.0–0.4)	0.0 (0.0–1.0)	0.11
Maximum number of vomit episodes in 24 hours, median (IQR)	0.0 (0.0–1.0)	0.0 (0.0–1.0)	0.79	0.0 (0.0–0.5)	0.0 (0.0–1.0)	0.12
Primary Care visit within 7 days of discharge, N (%)	2 (2.2%)	53 (6.3%)	0.07	7 (2.9%)	49 (6.9%)	0.02
ED revisit within 7 days of discharge, N (%)	6 (5.6%)	57 (6.8%)	0.65	18 (7.3%)	45 (6.4%)	0.61
IV rehydration in the ED within 7 days of discharge, N (%)	2 (2.3%)	22 (2.6%)	0.83	8 (3.5%)	16 (2.3%)	0.34
Hospitalization within 7 days of discharge, N (%)	3 (2.5%)	14 (1.6%)	0.53	5 (2.1%)	11 (1.6%)	0.59

* The score was based on symptoms during the follow-up period and was calculated at the day 14 follow-up.

** This modified score includes diarrhea and vomiting duration, maximum diarrhea and vomiting episodes, and maximum fever temperature, and excludes additional healthcare visits and medical treatment.

MVS, Modified Vesikari Scale; hrs, Hours; ED, Emergency Department; IV, intravenous.

P-values are from Wilcoxon rank-sum tests for outcomes described with median (IQR) and Likelihood ratio tests for outcomes described with N (%).

Residential ZIP Code used to determine household income variables.

Threshold for ZIP Code Median Income: < $24,339 in 2016 US dollars, the poverty threshold in 2016 for 2 adults/2 children. Threshold for Percent of ZIP Code Below Poverty: > 31.5%, the upper quartile of observed values.

Table 3.

Post-enrollment Modified Vesikari Scale(21, 22) score as a continuous variable. Results from univariable and multivariable mixed linear regression models.

	Univariable Models		Multivariable Model 1†		Multivariable Model 2‡	
Predictor	**Regression Coefficient (95% CI)**	***P*-value**	**Regression Coefficient (95% CI)**	***P*-value**	**Regression Coefficient (95% CI)**	***P*-value**
Patient ZIP Code median income is below the national poverty threshold (vs. Not)	−0.34 (−1.09, 0.41)	.37	−0.29 (−1.03, 0.45)	.44	Not Included	
Patient ZIP Code is in the lowest household income quartile based on percent below poverty (vs. Not)	−0.60 (−1.13, −0.07)	.03	Not Included		−0.45 (−0.97, 0.06)	.09
Male (vs. Female)	0.28 (−0.13, 0.70)	.18	0.33 (−0.07, 0.73)	.10	0.33 (−0.07, 0.73)	.11
Number in household (1 person increase)	−0.07 (−0.20, 0.05)	.25	−0.07 (−0.19, 0.05)	.24	−0.07 (−0.19, 0.04)	.22
Race/Ethnicity (vs. White Non-Hispanic)*		<.001		.008		.02
Black Non-Hispanic	−1.05 (−1.66, −0.43)	<.001	−0.72 (−1.36, −0.08)	.03	−0.63 (−1.28, 0.01)	.05
Hispanic	−1.25 (−1.89, −0.61)	<.001	−1.04 (−1.67, −0.40)	.001	−0.95 (−1.59, −0.31)	.004
Other/Unknown	−0.53 (−1.38, 0.31)	.22	−0.25 (−1.08, 0.58)	.56	−0.21 (−1.04, 0.62)	.62
Baseline MVS score(21, 22) (1-unit change)	0.28 (0.21, 0.35)	<.001	0.26 (0.18, 0.33)	<.001	0.26 (0.18, 0.33)	<.001
Clinical Dehydration Scale score at Enrollment(27)	0.40 (0.23, 0.57)	<.001	0.18 (0.00, 0.35)	.05	0.18 (0.00, 0.36)	.05
Infectious Agent (vs. Negative)*		.01		.05		.04
Isolated Virus	0.73 (0.24, 1.21)	.003	0.26 (−0.23, 0.74)	.30	0.26 (−0.22, 0.74)	.29
Isolated Bacteria	0.25 (−0.67, 1.16)	.60	0.52 (−0.36, 1.41)	.25	0.58 (−0.31, 1.47)	.20
Parasite	1.36 (−0.77, 3.49)	.21	1.20 (−0.87, 3.27)	.26	1.21 (−0.86, 3.27)	.25
Virus/Bacteria Co-detection	2.56 (0.15, 4.98)	.04	3.01 (0.66, 5.37)	.01	3.00 (0.66, 5.34)	.01
Not Tested	−0.05 (−0.66, 0.56)	.88	−0.28 (−0.86, 0.31)	.36	−0.27 (−0.85, 0.31)	.36
Child saw a doctor prior to enrollment ED visit (vs. Not)	0.53 (0.01, 1.05)	.04	−0.11 (−0.64, 0.41)	.68	−0.12 (−0.64, 0.40)	.65
Child Received Rotavirus Vaccine (vs. Not)	0.51 (−0.09, 1.10)	.09	0.45 (−0.13, 1.04)	.13	0.45 (−0.13, 1.03)	.13
Received Probiotic (vs. Placebo)	−0.05 (−0.46, 0.37)	.82	−0.06 (−0.47, 0.34)	.75	−0.06 (−0.46, 0.34)	.78

ED, Emergency Department; MVS, Modified Vesikari Scale.

†Multivariable Model 1: Analyzes median income based on relationship to the national poverty threshold. Threshold for ZIP Code Median Income: < $24,339 in 2016 US dollars, the poverty threshold in 2016 for 2 adults/2 children.

‡Multivariable Model 2: Analyzes median income with study population divided into quartiles with low socio-economic status defined by being in the lowest quartile. Threshold for Percent of ZIP Code Below Poverty: > 31.5%, the upper quartile of observed values. Random intercept for each enrolling center included in both models. Zip Code was not included in the model due to co-linearity with median income and our desire to model each separately.

*P-value testing for an overall association.