



Risk factors of diarrheal disease among children in the East African countries of Burundi, Rwanda and Tanzania

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ABSTRACT

Diarrheal diseases are a leading cause of childhood morbidity and mortality globally and in East Africa. Determining diarrheal disease risk factors and their strength of association to diarrheal disease in this region is necessary to identify and prioritize future research questions and interventions. Demographic and Health Surveys (DHS) Program Data on child health in Burundi, Rwanda, and Tanzania from 2010 were used and simple and multiple logistic regressions were completed to determine factors that predicted diarrheal disease. Diarrhea that occurred in the two weeks prior to data collection was reported for 24.80% of Burundian, 13.1% of Rwandan, and 13.91% of Tanzanian children under five. In Burundian children, increased risk of diarrhea was associated with unimproved sanitation, young mothers, and the mother's education level (secondary school or less). In Rwandan children, increased risk of diarrhea was associated with more than 30-minute travel time to water source, rainy season, young mothers, mother's lack of education, and low wealth index. In Tanzanian children, increased risk of diarrhea was associated with rainy season and young mothers. The impact of improved water source and sanitation facility on diarrheal disease is not consistent across the literature or results of this study. Future research should include information on hygiene practices, type of water storage container and types of household water treatment. Further, pathogen specific research, such as molecular fingerprinting, would assist to link the source to the disease. These additions would provide a more comprehensive understanding of risk factors for and sources of diarrheal disease globally and in East Africa.

INTRODUCTION

Diarrheal diseases are a major public health burden, killing 1.8 million people annually and disproportionately affecting children in developing countries.^{1,2} Globally, diarrhea is the second leading cause of death of children under five, with approximately 760,000 of these children dying annually.² In sub-Saharan Africa, diarrhea is the primary cause of childhood morbidity and mortality.³ Most diarrheal cases can be prevented using safe drinking water, basic hygiene and sanitation measures.² Diarrheal diseases are more prevalent in

the rainy season⁴ and associated with socioeconomic status,⁵ especially with mother's educational status.^{6,7} The objective of this project was to determine factors that predicted diarrheal disease in children under five in Burundi, Rwanda, and Tanzania in 2010 using the Demographic and Health Survey (DHS) Program data on child health.

METHODS

Data were obtained from the DHS program (2010) on child health for Burundi (N=7198), Rwanda (N=8418), and Tanzania (N= 7295). The DHS child health survey

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collects data on childhood vaccinations, prevention and treatment of acute respiratory infections and fever, hand-washing materials and facilities, and diarrhea prevalence, knowledge, and treatment. Factors considered for association with diarrhea included: source of drinking water, time to travel to water source, type of sanitation facility, seasonality, wealth index, age of the mother, and education level of the mother. Several variable transformations were performed. Variables for type of sanitation facility and water source were transformed to categories of improved sources and facilities or not improved based on WHO and UNICEF definitions.⁸ Time to water source was transformed to 15-minute intervals. There are no recommendations in the literature regarding acceptable or desirable travel time. Month of interview was transformed to dry and rainy season based on World Bank rainfall records for each country.⁹ Mother's current age was categorized to

represent ages with risk associations. Wealth index was transformed to poorer than middle income, middle income, and richer than middle income. Highest educational level was used without transformation. IBM SPSS Statistics Version 22 (IBM Corp., Armonk, NY) software was used to complete all analyses. Descriptive statistics were completed for all variables. Simple and multiple logistic regressions were completed to determine factors that predicted diarrheal disease in the previous two weeks. All variables were controlled for in the final model. Odds ratios and confidence intervals were reported.

RESULTS

Tables 1, 3, and 5 display percentages of diarrhea for each variable by country and Tables 2, 4, and 6 illustrate multiple regression output for factors that predicted diarrhea in the previous two weeks by country.

Table 1 Diarrhea Prevalence in the Last Two Weeks and Risk Factors, Burundi 2010

	Yes	No	Total
	N (%)	N (%)	N (%)
Diarrhea in the Last Two Weeks, N=7198	1787 (24.8%)	5411 (75.2%)	7198 (100%)
Time to Water Source			
≤15 minutes	601 (8.35%)	1844 (25.62%)	2445 (33.97%)
16-29 minutes	568 (7.89%)	1616 (22.45%)	2184 (30.34%)
≥30 minutes	618 (8.59%)	1951 (27.10%)	2569 (35.69%)
Type of Water Source			
Improved	1314 (18.26%)	4081 (56.7%)	5395 (74.95%)
Unimproved	473 (6.57%)	1330 (18.48%)	1803 (25.05%)
Type of Sanitation Facility			
Improved	664 (9.24%)	2365 (32.90%)	3029 (42.14%)
Unimproved	1122 (15.61%)	3037 (42.25%)	4159 (57.86%)
Interview Season			
Rainy Season	1639 (22.77%)	4828 (67.07%)	6467 (89.84%)
Dry Season	148 (2.06%)	583 (8.10%)	731 (10.16%)
Mother's Age			
≤18 years	22 (0.31%)	51 (0.71%)	73 (1.01%)
19- 34 years	1336 (18.56%)	3718 (51.65%)	5054 (70.21%)
≥35 years	429 (5.96%)	1642 (22.82%)	2071 (28.77%)
Mother's Education Level			
No Education	892 (12.39%)	2600 (36.12%)	3492 (48.51%)
Primary School	762 (10.59%)	2217 (30.80%)	2979 (41.39%)
Secondary School	127 (1.76%)	502 (6.97%)	629 (8.74%)



Higher	6 (0.00%)	92 (1.28%)	98 (1.36%)
Wealth Index			
Poorer than middle income	751 (10.43%)	1998 (27.76%)	2749 (38.46%)
Middle income	335 (4.65%)	1026 (14.25%)	1361 (18.91%)
Wealthier than middle income	701 (9.74%)	2387 (33.16%)	3088 (42.90%)

Diarrhea in the last two weeks was reported for 24.8% of Burundian, 13.2% of Rwandan, and 13.91% of Tanzanian children under five. Rwandan children in homes with water sources less than fifteen minutes away were 22.5% less likely to have diarrhea than those with water sources more than thirty minutes away (OR= 0.775 CI= 0.663, 0.906). Time to water source was not significantly associated with risk of

diarrhea in Burundian or Tanzanian children. Improved water source was not significantly associated with diarrhea risk in any of the three countries. Improved sanitation facility was significant associated with reduced childhood diarrhea only in Burundi (OR=0.833 CI=0.739, 0.938), signifying that those with improved water sources were 16.7% less likely to report diarrhea in the last two weeks.

Table 2 Multiple Regression: Risk Factors for Diarrhea in the Last Two Weeks in Burundi

Variables	N=7198 OR (95% CI)
Time to Water Source	
≤15 minutes	0.977 (0.857, 1.113)**
16-29 minutes	1.046 (0.915, 1.196)**
≥30 minutes	1.00*
Type of Water Source	
Improved	0.970 (0.857, 1.098)**
Unimproved	1.00*
Type of Sanitation Facility	
Improved	0.833 (0.739, 0.938)
Unimproved	1.00*
Interview Season	
Rainy Season	1.008 (0.814, 1.248)**
Dry Season	1.00*
Mother's Age	
≤18 years	1.749 (1.045, 2.925)
19- 34 years	1.401 (1.234, 1.590)
≥35 years	1.00*
Mother's Education Level	
No Education	1.00*
Primary School	0.968 (0.860, 1.090)**
Secondary School	0.805 (0.638, 1.017)**
Higher	0.224 (0.096, 0.523)
Wealth Index	
Poorer than middle income	1.117 (0.976, 1.278)**
Middle income	1.005 (0.858, 1.177)**
Wealthier than middle income	1.00*

* Indicates reference category

** Not statistically significant



Rwandan and Tanzanian children whose mothers were interviewed in rainy season were 50% (OR= 1.502 CI= 1.306, 1.728) and 41% (OR= 1.412 CI= 1.209, 1.649) more likely to report diarrhea in the last two weeks. Season was not significantly associated with childhood diarrhea risk in Burundi. In all three countries, children of mothers age eighteen or younger were more likely to have diarrhea in the last two weeks compared to children of mothers age

thirty-five or older (Burundi OR= 1.749 CI= 1.045, 2.925) (Rwanda OR= 2.001 CI=1.066, 3.757) (Tanzania OR= 2.230 CI= 1.526, 3.259). In all three countries, children of mothers age nineteen to thirty-four years were more likely to have diarrhea than children of mothers age thirty-five and older (Burundi OR=1.401 CI= 1.234, 1.590) (Rwanda OR= 1.360 CI= 1.166,1.585) (Tanzania OR 1.307 CI= 1.113, 1.534).

Table 3 Diarrhea Prevalence in the Last Two Weeks and Risk Factors, Rwanda 2010

	Yes	No	Total
	N (%)	N (%)	N (%)
Diarrhea in the Last Two Weeks, N=8418	1109 (13.2%)	7309 (86.8%)	8418 (100%)
Time to Water Source			
≤15 minutes	344 (4.1%)	2835 (30.1%)	2879 (34.2%)
16-29 minutes	356 (4.2%)	2438 (29.0%)	2794 (33.2%)
≥30 minutes	409 (4.9%)	2336 (27.8%)	2745 (32.6%)
Type of Water Source			
Improved	718 (8.5%)	5082 (60.4%)	5800 (68.9%)
Unimproved	391 (4.6%)	2223 (26.4%)	2614 (31.1%)
Type of Sanitation Facility			
Improved	767 (9.1%)	5344 (63.6%)	6111 (72.7%)
Unimproved	341 (4.1%)	1957 (23.3%)	2298 (27.3%)
Interview Season			
Rainy Season	785 (9.3%)	4444 (52.8%)	5229 (62.1%)
Dry Season	324 (3.8%)	2865 (34.0%)	3189 (37.9%)
Mother's Age			
≤18 years	13 (0.2%)	51 (0.6%)	64 (0.8%)
19- 34 years	854 (10.1%)	5223 (62.0%)	6077 (72.2%)
≥35 years	242 (2.9%)	2035 (24.2%)	2277 (27.0%)
Mother's Education Level			
No Education	174 (2.1%)	1393 (16.5%)	1567 (18.6%)
Primary School	843 (10.0%)	5209 (61.9%)	6052 (71.9%)
Secondary School	88 (1.0%)	609 (7.2%)	697 (8.3%)
Higher	4 (<0.01%)	98 (1.2%)	102 (1.2%)
Wealth Index			
Poorer than middle income	556 (6.6%)	3158 (37.5%)	3714 (44.1%)
Middle income	202 (2.4%)	1450 (17.2%)	1652 (19.6%)
Wealthier than middle income	351 (4.2%)	2701 (32.1%)	3052 (36.3%)

In Burundi and Rwanda, children of mothers who received more than secondary education were less likely to have had diarrhea in the last two weeks than

those with no education (Burundi OR= 0.224 CI= 0.096, 0.523) (Rwanda OR=0.351 CI= 0.126, 0.977). In Rwanda, children of mothers with education levels of secondary (OR= 1.361 CI= 1.017, 1.820) or primary



school (OR= 1.309 CI= 1.096, 1.563) were more likely to have diarrhea in the previous two weeks than those of mothers with no education. Mother's education level was not significantly associated with childhood diarrhea risk in Tanzania. Rwandan children of mothers who were categorized as poorer

than middle income were 23.8% more likely to have diarrhea in the previous two weeks than children of mothers who were categorized as wealthier than middle income (OR=1.238 CI= 1.050, 1.460). Wealth index was not significantly associated with childhood diarrheal risk in Burundi or Tanzania.

Table 4 Multiple Regression: Risk Factors for Diarrhea in the Last Two Weeks in Rwanda

Variables	N=8418 OR (95% CI)
Time to Water Source	
≤15 minutes	0.775 (0.663, 0.906)
16-29 minutes	0.814 (0.697, 0.950)
≥30 minutes	1.00*
Type of Water Source	
Improved	0.879 (0.767, 1.008)**
Unimproved	1.00*
Type of Sanitation Facility	
Improved	0.911 (0.785, 1.057)**
Unimproved	1.00*
Interview Season	
Rainy Season	1.502 (1.306, 1,728)
Dry Season	1.00*
Mother's Age	
≤18 years	2.001 (1.066, 3.757)
19- 34 years	1.306 (1.166, 1.585)
≥35 years	1.00*
Mother's Education Level	
No Education	1.00*
Primary School	1.309 (1.096, 1.563)
Secondary School	1.361 (1.017, 1.820)
Higher	0.351 (0.126, 0.977)
Wealth Index	
Poorer than middle income	1.238 (1.050, 1.460)
Middle income	1.016 (0.840, 1.230)**
Wealthier than middle income	1.00*

* Indicates reference category

** Not statistically significant

Table 5 Diarrhea Prevalence in the Last Two Weeks and Risk Factors, Tanzania 2010

	Yes	No	Total
	N (%)	N (%)	N (%)
Diarrhea in the Last Two Weeks, N=7295	1015 (13.91%)	6280 (86.09%)	7295 (100%)
Time to Water Source			
≤15 minutes	380 (5.21%)	2213 (30.34%)	2593 (35.54%)

16-29 minutes	267 (3.66%)	1735 (23.78%)	2002 (27.44%)
≥30 minutes	368 (5.04%)	2332 (31.97%)	2700 (37.01%)
Type of Water Source			
Improved	555 (7.61%)	3331 (45.66%)	3886 (53.27%)
Unimproved	460 (6.31%)	2949 (40.42%)	3409 (46.73%)
Type of Sanitation Facility			
Improved	191(2.62%)	1273 (17.45%)	1464 (20.07%)
Unimproved	824 (11.30%)	5007 (68.64%)	5831 (79.93%)
Interview Season			
Rainy Season	698 (9.57%)	4006 (54.91%)	4704 (64.48%)
Dry Season	317 (4.35%)	2274 (31.17%)	2591 (35.52%)
Mother's Age			
≤18 years	40 (0.55%)	143 (1.96%)	183 (2.51%)
19- 34 years	753 (10.32%)	4423 (60.63%)	5176 (70.95%)
≥35 years	222 (3.04%)	1714 (23.50%)	1936 (26.54%)
Mother's Education Level			
No Education	255 (3.50%)	1618 (22.18%)	1873 (25.68%)
Primary School	648 (8.88%)	3926 (53.92%)	4574 (62.70%)
Secondary School	108 (1.48%)	720 (9.87%)	828 (11.35%)
Higher	4 (0.03%)	16 (0.22%)	20 (0.27%)
Wealth Index			
Poorer than middle income	428 (5.87%)	2717 (37.24%)	3145 (43.11%)
Middle income	221 (3.03%)	1333 (18.27%)	1554 (21.30%)
Wealthier than middle income	366 (5.02%)	2230 (30.57%)	2596 (35.59%)

Table 6 Multiple Regression: Risk Factors for Diarrhea in the Last Two Weeks in Tanzania

Variables	N=7198 OR (95% CI)
Time to Water Source	
≤15 minutes	0.977 (0.857, 1.113)**
16-29 minutes	1.046 (0.915, 1.196)**
≥30 minutes	1.00*
Type of Water Source	
Improved	0.970 (0.857, 1.098)**
Unimproved	1.00*
Type of Sanitation Facility	
Improved	0.833 (0.739, 0.938)
Unimproved	1.00*
Interview Season	
Rainy Season	1.008 (0.814, 1.248)**
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Mother's Age	
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≥35 years	1.00*

Mother's Education Level	
No Education	1.00*
Primary School	0.968 (0.860, 1.090)**
Secondary School	0.805 (0.638, 1.017)**
Higher	0.224 (0.096, 0.523)
Wealth Index	
Poorer than middle income	1.117 (0.976, 1.278)**
Middle income	1.005 (0.858, 1.177)**
Wealthier than middle income	1.00*

* Indicates reference category

** Not statistically significant

DISCUSSION

Although demonstrated as important in one of three countries in our study, closer water sources are reported to be important for reducing childhood diarrhea in other studies.¹⁰ There are several possible explanations for time to water source being associated with increased risk of diarrhea in children. Increased time to source may mean reduced quantity of water, effecting hygiene standards in the home. Second, increased time to water source may mean longer storage time, increasing risk of recontamination or growth of pathogens during storage. Because travel time is associated with increased risk we suggest that point of use rather than point of collection filtration and improved safe storage conditions should be used. Lack of association with improved water sources and inconsistent findings for sanitation facilities may be because improvement did not prevent contamination or recontamination at point-of-use, and more than one type of source and facility may be used by respondents. Currently the impact of improved water source on diarrheal illnesses is not consistent across the published literature and investigations to determine why are needed.^{4, 11, 12, 13} Future research would benefit from addition of items addressing hygiene practices, type of water storage container, and types of water treatment or filtration to the surveys used by DHS. Further investigation is also needed into whether water sources and sanitation facilities that meet "improved" definitions are safe. One study indicated that some water sources that meet "improved" standards are still unsafe for consumption, with 10% being considered high risk (containing at least 100 *Escherichia coli* per 100 ml).¹⁴

Seasonality of diarrhea was important in this study and other studies^{4, 15} and is an area for further research. Future research should include the effectiveness of season specific interventions such as educational campaigns, modified treatment methods and changes in distribution. Consistent with other studies, associations were found for socioeconomic factors of the mother including age, education, and wealth with childhood diarrheal risk, and may influence hygiene practices including point of use behaviors.^{5, 6} Lack of association with mother's education level in Tanzania and with mother's wealth in Burundi could be due to the close relationship between these two factors. Regression methodology of calculating association of each factor controlling for all other factors may lead to lack of associations when factors are highly linked, such as socioeconomic factors. Future research in these areas will help to provide a greater understanding of the relationship between socioeconomic factors and diarrheal disease risk. Data limitations include cross-sectional data, missing data, and data not collected. Further, the age, education, and wealth of the mother are likely interrelated and could be having an interactive effect.

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