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Risk Factors for Diarrhea in Children under Five Years of Age Residing in Peri-urban Communities in Cochabamba, Bolivia

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Abstract. This study examined the relationship between childhood diarrhea prevalence and caregiver knowledge of the causes and prevention of diarrhea in a prospective cohort of 952 children < 5 years of age in Cochabamba, Bolivia. The survey of caregiver knowledge found that more than 80% of caregivers were unaware that hand washing with soap could prevent childhood diarrhea. Furthermore, when asked how to keep food safe for children to eat only 17% of caregivers reported hand washing before cooking and feeding a child. Lack of caregiver awareness of the importance of practices related to hygiene and sanitation for diarrhea prevention were significant risk factors for diarrheal disease in this cohort. The knowledge findings from this study suggest that health promotion in these communities should put further emphasis on increasing knowledge of how water treatment, hand washing with soap, proper disposal of child feces, and food preparation relate to childhood diarrhea prevention.

INTRODUCTION

Globally, nearly 1 million deaths annually in children < 5 years of age are attributed to diarrhea.[1] In Bolivia, diarrhea is the third leading cause of morbidity and mortality in children < 5 years of age.[1] Diarrhea surveillance from national surveys for the country indicate an alarming rise in the diarrhea prevalence for this age group over time from 19.2% in 1998 to 31.3% in 2008. In Cochabamba, Bolivia, the site of this study, the most recent government survey from 2008 reported a diarrhea prevalence of 36.2% for children < 5 years of age for the department.[2]

Previous studies have identified risk factors for diarrhea such as younger age,[3,4] male gender,[4,5] early weaning,[5–8] seasonal patterns,[5,7,9] low maternal education,[5,9,10] lack of piped water supply,[9,11–15] poor water-storage practices,[9,14–18] younger maternal age,[11,12] lack of hand washing with soap by caregiver,[18,19] poor sanitation,[9,16,18,20,21] visible feces in the yard,[4] indiscriminate disposal of child feces,[17] unsatisfactory garbage disposal,[11] shorter boiling time,[13] using water from cistern trucks,[13] and not treating water in the home.[13]

In a recent multisite study it was found that rotavirus was the most common cause of moderate to severe diarrhea in children 0–23 months of age, and shigellosis for the age group 24–59 months of age.[22] A few studies have assessed risk factors for diarrhea by enteric pathogens. In Kosek and others,[9] age, maternal education, floor type, and rainy season were found to be significant risk factors for shigellosis in children < 5 years of age. For *Campylobacter*, maternal education and household water connection were found to be significant risk factors for this age group.[12] In Blake and others, where five enteric pathogens were compared differences were observed in risk factors between pathogens for children < 5 years of age. For example exclusive breastfeeding was protective for shigella, however not for rotavirus or enterotoxigenic *Escherichia coli*.[8]

Numerous studies from Latin America, Asia, and Africa have found limited knowledge of the pathogenic causes of diarrhea among caregivers of young children in low resource settings.[23–25] In many cultures it is believed that diarrhea is a normal part of growing, and is attributed to causes such as an imbalance of hot and cold foods, infant teething, the evil eye, or a mother's emotional state.[24,26–28] Despite these findings, there have only been a handful of published studies that have assessed the relationship between caregiver knowledge of diarrhea prevention and child diarrhea outcomes.[29–31] In Dikassa and others[30] there was a significant association found between caregiver knowledge of transmission routes of diarrheal disease such as feces and poor hygiene and decreased odds of childhood diarrhea episodes. Consistent with this finding, in Bertrand and others[31] a significant association was found between diarrhea prevalence and mother's general knowledge of causes of diarrhea and prevention. However, it is also important to mention the extensive literature that exists showing that knowledge alone is often not sufficient to change behavior and that contextual, psychosocial, and technological factors all play a role in facilitating water, sanitation, and hygiene behavior change.[32–36]

Effective interventions to target previously identified knowledge and behavioral risk factors for diarrheal disease in children include promotion of hand washing with soap, hygiene education, latrine installation at the household and community level, municipal water connection, water kiosk, household-based chlorination, filtration, solar disinfection, and improved water storage.[37–40]

However, risk factors for childhood diarrhea vary by population with some factors being more important than others in particular settings. Therefore, it is important to identify the distinct risk factors for diarrhea in a particular target population so disease control programs can be implemented that are tailored to target these risk factors.

In this study, we investigate potential risk factors for diarrheal disease in peri-urban communities in Cochabamba, Bolivia. This study is nested within a cluster randomized controlled trial of the effectiveness of water filters and/or hygiene and a sanitation education program, thereby providing the unique opportunity to evaluate how risk factors change within

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a population with the implementation of a water, sanitation, and hygiene intervention in comparison to a control group. To our knowledge, this is the first published study to look at risk factors for diarrhea in peri-urban communities in Cochabamba, Bolivia.

METHODS

Study population. This prospective cohort study was conducted in eight peri-urban zones southeast and adjacent to the city of Cochabamba, located in the Cochabamba Department of Bolivia. Zones were selected that lacked access to municipal water and sanitation through a piped network. This study was conducted in collaboration with Fundación contra el Hambre–Bolivia (Food for the Hungry).

Study design. This prospective cohort study was nested in a cluster randomized controlled trial of a hollow fiber water filter and/or sanitation and hygiene interventions (Cochabamba WASH RCT). There were four study arms: 1) a control arm that received teachings on life skills (e.g., budget and family skills) not related to water and sanitation; 2) an arm that received a PointONE Filter and a 30 L bucket (with lid) with training on use and maintenance; 3) an arm that received WASH behavior change communication (BCC); and 4) an arm that received a PointONE Filter and 30 L bucket (with lid), plus WASH BCC education.

Eligibility and enrollment. In November 2009, the peri-urban zones were screened to find children that met the following study eligibility criteria: 1) < 60 months of age, 2) lived in squatter or low-income rental housing, 3) received their primary drinking/household water from a non-municipal source, and 4) lived in a household that lacked access to a direct municipal sewer line. Enrollment was limited to one child per household. If more than one child < 60 months of age resided in a household the youngest child was selected.

Data collection. All children enrolled were followed prospectively from March to August 2009. At baseline, a 30-minute Knowledge Practices and Coverage (KPC) survey on socio-demographic variables was administered to each household's primary caregiver. In a subset of 306 randomly selected households a more intensive 60-minute KPC survey was administered, which included questions on primary caregiver on knowledge cause and prevention of diarrheal diseases in children.

We looked at 24 risk factors for childhood diarrhea previously identified in the literature (Tables 1–3).[4–21,41] These risk factors were on water, sanitation, hygiene, and knowledge of the causes of childhood diarrheal disease and prevention. All of these variables were obtained from the baseline KPC survey administered to the primary caregiver in each household. The knowledge questions were all asked as open-ended questions with multiple responses allowed. These open-ended responses were then coded and put into categories. All other questions had fixed multiple choice responses.

Diarrhea surveillance. For the duration of the study period from March to August 2009, a monthly visit was made to each child's household by a health technician to obtain 2-week recall data from the child's primary caregiver on the presence of diarrhea in the enrolled child. Diarrhea was defined as three or more loose stools over a 24-hour period. Surveillance data were collected using Pocket PC Creations v. 5.0 for rapid entry into handheld PCs (HP iPAQ 110 Windows Mobile Handheld, Hewlett-Packard Company, Palo Alto, CA).

Statistical methods. We were interested in whether the 2-week period prevalence of diarrhea in children < 5 years of age was associated with demographic, household, and diarrhea knowledge characteristics among participants of Cochabamba WASH RCT.[42]

In our recently published manuscript of the Cochabamba WASH RCT, we observed a very strong effect of water filter intervention on reducing diarrhea period prevalence.[42] To avoid confounding of environmental factors and knowledge with the impact of the filter intervention, we stratified our analysis by a filter and non-filter group. Generalized estimating equation models were to estimate the relationship between average diarrhea prevalence and each factor of interest.[43] Stratifying by the filter and non-filter groups allowed us to identify whether significant risk factors differed between study groups. As a result of our study design, we were only able to examine the bivariate association between diarrhea prevalence and one risk factor at a time. To assess the variability of these estimates, we resampled the diarrhea data by cluster in a bootstrap analysis within filter and non-filter groups.[44] We used the corrected (or accelerated) bootstrap confidence interval (CI) to define approximate CIs of average diarrhea prevalence for each level of risk factor under consideration. This correction is generally recommended when the bootstrap is applied to small samples.[45]

We interpreted these 95% CIs for the prevalence ratios as statistical tests of the association between each factor and the 2-week diarrhea period prevalence within each study group. Confidence intervals that overlap with 1.0 indicate that diarrhea prevalence for each given level of risk factor is the same as the reference level. Confidence intervals that do not overlap with 1.0 indicate that the diarrhea prevalence is statistically different at $\alpha = 0.05$, in the direction of that difference. It is possible to estimate standard errors for the prevalence ratio and with these standard errors approximate a P value using the methods of Hall and Wilson.[46] However, at eight in each strata, the small number of clusters is generally not sufficient to guarantee the assumptions of this procedure.[45]

Ethics. The study protocol was approved by the Messiah College Institutional Review Board. Informed consent was obtained from all study respondents.

RESULTS

A total of 952 children were followed prospectively for 5 months, 484 children received a water filter in their household and 468 children did not receive a water filter. There were no large differences observed between the filter and non-filter groups on any of the demographic variables measured (Table 1). The median age of these children was 20 months for both the filter and non-filter groups with the range being between 2 and 40 months. Forty-eight percent of the children were female, and the majority resided in households with Spanish being their primary language. The majority of caregivers had at least 6 years of formal education, and the main source of water for these households were tanker trucks. Of the 952 children followed, 65% had at least one household visit with caregiver-reported diarrhea. One percent of children had all household visits with caregiver-reported diarrhea. There were no significant differences in demographic variables observed between those households that received the intensive KPC survey and the standard version.

TABLE 1
Characteristics of the study population

	Total population	Non-filter group	Filter group
	% (*N*)	% (*N*)	% (*N*)
Number of children	952	484	468
Baseline age of child (months)			
Median ± SD (range)	20 ± 8.9 (2–40)	20 ± 9.0 (2–38)	20 ± 8.9 (3–40)
0–11	22% (207)	21% (101)	22% (106)
12–23	41% (392)	41% (197)	42% (195)
24–36	34% (326)	37% (183)	34% (159)
37–48	3% (27)	1% (3)	2% (8)
Number of visits with caregiver-reported diarrhea			
0 visits	35% (330)	14% (70)	56% (260)
1 visits	31% (294)	31% (152)	30% (142)
2 visits	20% (188)	29% (140)	10% (48)
3 visits	9% (86)	15% (72)	3% (14)
4 visits	4% (42)	8% (39)	1% (3)
5 visits	1% (12)	2% (11)	<1% (1)
Child gender			
Female	48% (455)	48% (230)	48% (225)
Male	52% (497)	52% (254)	52% (243)
Primary language spoken by household			
Aymara	3% (29)	2% (12)	3% (17)
Spanish	50% (476)	51% (248)	49% (228)
Quecha	47% (447)	46% (224)	48% (223)
Caregiver years of formal education			
None	11% (102)	9% (42)	13% (60)
1–5 Years	30% (282)	34% (165)	25% (117)
6–10 Years	31% (292)	30% (145)	31% (147)
> 10 Years	29% (276)	27% (132)	31% (144)
Main source of drinking water			
Tanker truck	88% (834)	88% (425)	87% (409)
Water coolers	7% (71)	9% (42)	6% (29)
Other	5% (47)	3% (17)	7% (30)

Caregiver knowledge. The majority of caregivers reported bad food as being the main cause of childhood diarrhea (65%) (Table 2). This was followed by cold (22%), and untreated water (14%). When asked how to keep food safe the majority of caregivers reported washing food before eating it (53%) followed by cooking food thoroughly (42%). Hand washing before eating and cooking was reported by only 9% and 8% of respondents, respectively. When asked the different ways that a person can prevent diarrhea 42% of caregivers reported food preparation, followed by water treatment at 31%, and hand washing at 27%.

Environmental and Demographic Factors. The use of water coolers was found to be protective for childhood diarrhea in the non-filter group (Diarrhea Prevalence Ratio [DPR]): 0.91 (95% Confidence Interval [CI]: 0.72, 0.97)). Male gender was a significant risk factor for childhood diarrhea in the filter group (DPR: 1.11 (95% CI: 1.01, 1.27)). For caregiver years of education, having 5–10 years of formal education was protective for childhood diarrhea in the filter group (DPR: 0.74 (95% CI: 0.53, 0.97)). Lack of caregiver knowledge of proper food preparation for diarrhea prevention was a significant risk factor for childhood diarrhea in the filter group (DPR: 1.20 (95% CI: 1.06, 1.39)), and the non-filter group (DPR: 1.32 (95% CI: 1.02, 1.96)). In the filter group, lack of caregiver knowledge of proper disposal of feces for diarrhea prevention was a significant risk factor for childhood (DPR: 1.64 (95% CI: 1.08, 3.13)). While lack of caregiver knowledge on hand washing for childhood diarrhea prevention was a significant risk factor in the non-filter group (DPR: 1.15 (95% CI: 1.04, 1.22)). None of the variables on the causes of diarrhea or how to keep food safe were found to be significantly associated with the diarrhea outcomes.

DISCUSSION

In this study, we investigated socioeconomic and knowledge risk factors for childhood diarrheal disease in peri-urban communities in Cochabamba, Bolivia. Because this study was nested within a cluster RCT, we had the opportunity to evaluate how risk factors change within a population with the implementation of a water, sanitation, and hygiene intervention in comparison to a control group. Because the intervention study only observed a significant impact of the water filter arms of the study, we stratified the study population to the non-filter and filter group.

The findings from this study showed that caregiver lack of awareness of practices related to personal and food hygiene for diarrhea prevention were a significant risk factors for diarrheal disease in this cohort of children < 5 years of age in Cochabamba, Bolivia. Although in this study we did not have a measure of actual household hygiene and food preparation practices, these findings suggest that these two knowledge factors are important in childhood diarrhea prevalence for this population. This is consistent with recent findings from Sima and others,[47] which found a significant association between food and household hygiene and childhood diarrhea prevalence. There was also a significant protective relationship in this study between knowledge of proper disposal of feces to prevent diarrhea and diarrhea prevalence. These finding are consistent with Dikassa and others and Bertrand and others,[30,31] which found that children of mothers that were less aware of the importance of child caretaker cleanliness and proper sanitary practices were at significantly higher risk of severe diarrheal disease. Intriguingly, the association between knowledge of proper feces disposal and reduced diarrhea prevalence was only found in the filter group, perhaps suggesting that once exposure through microbial contamination of drinking water is removed the transmission route through direct fecal oral contamination becomes more important.

Five gallon water bottles were found to be significantly protective in the non-filter group in comparison with the use of tanker trucks. This is consistent with another study conducted in Bolivia, which found that using off-network water from cistern trucks was a risk factor for pediatric diarrhea episodes.[13] These water coolers only dispensed water and did not filter it, and unfortunately we do not have information on the source of the 5 gallon water bottles. However, because of the cost they were typically used by wealthier households and presumably had higher quality water relative to microbial contamination.

The descriptive findings from this study indicate that diarrhea morbidity is high within this population, with a diarrhea prevalence of 40% in the non-filter group. This is higher than the prevalence of 24% in children < 5 years of age found in a rural area in the same department of the country.[48] Furthermore, 28% of the children in the non-filter group in this study had the majority of household visits with caregiver reported diarrhea.

The survey of caregiver knowledge of prevention of diarrhea indicated that nearly 70% of caregivers were unaware that water treatment could prevent childhood diarrhea. This finding is of concern when considering the high reduction in childhood diarrhea prevalence found with the use of the

TABLE 2
Baseline caregiver knowledge of diarrhea causes and prevention and diarrhea prevalence[1]

	Total study population ($N = 306$)		Non-filter group ($N = 156$)		Filter ($N = 150$)	
	%	Diarrhea prevalence	%	Diarrhea prevalence	%	Diarrhea prevalence
What are the different causes of diarrhea? (Open ended with multiple responses allowed)						
Bad food	65%	26%	66%	40%	64%	13%
Cold	22%	25%	21%	38%	23%	13%
Untreated water	14%	23%	13%	34%	15%	13%
Heat	9%	25%	10%	43%	9%	6%
Curses and evil eye	7%	26%	6%	–	8%	13%
Magic	1%	13%	<1%	–	1%	–
Don't know	13%	28%	12%	40%	14%	16%
Other	18%	22%	19%	36%	18%	10%
Can you tell me how you keep food safe to eat? (Open ended with multiple responses allowed)						
Washing food before eating	53%	26%	49%	37%	57%	14%
Cooking food thoroughly	42%	27%	44%	39%	41%	14%
Hand washing before eating	9%	23%	8%	36%	11%	8%
Hand washing before cooking	8%	27%	4%	33%	13%	17%
Don't know	17%	28%	19%	44%	15%	14%
Other	6%	15%	6%	–	6%	–
What are the different ways that a person can prevent diarrhea?(Open ended with multiple reponses allowed)						
Proper food preparation	42%	23%	40%	35%	44%	11%
Water treatment	31%	25%	21%	41%	41%	12%
Hand washing (soap not mentioned)	27%	24%	37%	36%	17%	11%
Hand washing (soap mentioned)	18%	23%	15%	34%	21%	10%
Proper food storage	17%	24%	17%	38%	18%	9%
Proper disposal of feces/use of latrines	8%	24%	7%	37%	8%	8%
Don't know	6%	26%	6%	–	5%	–
Other	26%	26%	25%	40%	27%	13%

[1] Diarrhea prevalence was excluded for categories with less than 10 reponses.

PointONE Filter.[42] In addition, more than 80% of caregivers were unaware that hand washing with soap could prevent childhood diarrhea.

The majority of caregivers attributed diarrhea to bad food. The second most common cause was cold, and a small subset of caregivers thought diarrhea was attributed to heat, curses, the evil eye, and magic. These findings are consistent with other studies in which caregivers reported that diarrhea was attributed to magic or the evil eye.[24,26,27,49,50] Furthermore, in many areas within Latin America, it is a common cultural belief that an imbalance of hot and cold can cause illness.[51]

Beliefs of the causes of childhood diarrhea have been previously reported to affect water treatment behavior.[52] Therefore, promoting water treatment and hand washing with soap behaviors with messages on childhood diarrhea prevention may not be effective in cultures where diarrhea is not perceived as a health problem or where the link between these behaviors and childhood diarrhea is not well understood.[23,53] This could serve as a barrier to effective WASH BCC. Therefore, beliefs around the causes of childhood diarrhea should be well understood in communities before WASH communication campaigns are implemented.

Rotavirus has been found to be one of the leading enteric infections in children < 2 years of age in Bolivia.[54,55] The Bolivian Ministry of Health introduced rotavirus vaccine in 2008.[56] Unfortunately, in this study systematic data on rotavirus vaccination was not collected. Future studies should evaluate how rotavirus vaccination impacts risk factors for diarrhea in low income country settings.

There are several limitations to this study. First, we did not have indicators of actual water sanitation and hygiene practices, only the knowledge of these behaviors. Second, the risk factors we found are likely age dependent, especially those related to water quality that would have little impact on children that are primarily breastfed. However, because of our small numbers of clusters we were unable to provide detailed risk factor information by age category. Third, only a subset of 306 households in our present study population received the intensive KPC survey on knowledge of causes and prevention of childhood diarrhea. Finally, because our study design only included 16 clusters, we were unable to conduct multivariate regression modeling, which would allow us to look at the impact of multiple risk factors in a single model.

In conclusion, this study was able to show that lack of caregiver personal, food hygiene, and sanitation-related knowledge on diarrhea prevention were significant risk factors for diarrheal disease in children < 5 years of age in Cochabamba, Bolivia. Although the sample size was small after stratifying by filter and non-filter groups, statistically significant associations were still identified. The knowledge findings from this study suggest that health promotion programs should place further emphasis on increasing knowledge of how water treatment, hand washing with soap, proper disposal of child feces, and food preparation relates to childhood diarrhea prevention.

Future studies should evaluate behavioral risk factors for diarrhea in this study population, and conduct further formative research to identify cultural beliefs among caregivers of small children on diarrhea prevention. This information can be used to develop tailored communication messages promoting water treatment, improved sanitation, and hand washing with soap for this susceptible population.

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TABLE 3
Association of risk factors with diarrhea of children in Cochabamba, Bolivia

	Non-filter group			Filter group		
	N	Diarrhea prevalence	Diarrhea prevalence ratio	N	Diarrhea prevalence	Diarrhea prevalence ratio
Socioeconomic factors						
Child gender (%)						
Female	230	39%		225	13%	
Male	254	40%	1.03 (0.94, 1.12)	243	14%	1.11 (1.01, 1.27)
Primary language spoken by household						
Aymara	12	42%	1.11 (0.97, 1.19)	17	17%	1.27 (0.52, 2.52)
Spanish	248	38%		228	13%	
Quecha	224	41%	1.06 (0.96, 1.17)	223	14%	1.01 (0.85, 1.29)
Main source of drinking water						
Tanker truck	425	40%		409	14%	
Water coolers	42	36%	0.91 (0.72, 0.97)	29	12%	0.87 (0.40, 1.42)
Other	17	40%	1.00 (0.72, 1.68)	30	14%	1.05 (0.22, 1.81)
Caregiver years of education						
None	42	38%		60	17%	
1–5 Years	165	42%	1.11 (0.93, 1.34)	117	14%	0.84 (0.67, 1.13)
5–10 Years	145	36%	0.96 (0.88, 1.11)	147	12%	0.72 (0.53, 0.97)
Greater than 10 Years	132	40%	1.04 (0.88, 1.28)	144	14%	0.85 (0.53, 1.16)
Knowledge factors						
What are the different ways that a person can prevent diarrhea? (Open-ended with multiple responses allowed)						
Hand washing (soap not mentioned)						
Yes	57	36%		26	11%	
Not mentioned	99	41%	1.15 (1.04, 1.22)	124	13%	1.18 (0.96, 1.47)
Hand washing (soap mentioned)						
Yes	24	34%		32	10%	
Not mentioned	132	40%	1.19 (0.93, 1.61)	118	13%	1.28 (0.71, 2.94)
Water treatment						
Yes	33	41%		62	12%	
Not mentioned	123	39%	0.94 (0.74, 1.18)	88	13%	1.16 (0.78, 1.54)
Proper disposal of feces/use of latrines						
Yes	11	37%		12	8%	
Not mentioned	145	40%	1.08 (0.74, 1.75)	138	13%	1.64 (1.08, 3.13)
Proper food storage						
Yes	26	38%		27	9%	
Not mentioned	130	40%	1.05 (0.91, 1.59)	123	14%	1.59 (0.89, 3.03)
Proper food preparation						
Yes	63	35%		66	11%	
Not mentioned	93	42%	1.20 (1.06, 1.39)	84	14%	1.32 (1.02, 1.96)

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