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ORIGINAL RESEARCH

Water sanitation, access, use and self-reported diarrheal disease in rural Honduras

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ABSTRACT

Introduction: Only 79% of individuals living in rural Honduras use improved water sources. Inadequate drinking water quality is related to diarrheal illness, which in Honduras contributes to 18.6 episodes of diarrhea per child year in children under five years of age. The purpose of this study was to examine and compare access to drinking water and sanitation, as well as self-reported diarrheal disease incidence among three proximal communities in the Department of Yoro area of Honduras.

Methods: An 11-item language-specific, interviewer-administered, anonymous questionnaire was administered to 263 randomly selected adults attending a June 2011 medical brigade held in the communities of Coyoles, La Hicaca, and Lomitas. Chi-square with Fisher exact tests were utilized to compare water access, sanitation, and self-reported diarrheal incidence among these communities.

Results: Coyoles and La Hicaca used private faucets as their primary water sources. Coyoles had the greatest use of bottled water. Lomitas used rivers as their primary water source, and did not use bottled water. Mostly, females were responsible for acquiring water. Usage of multiple water sanitation methods was most common in Coyoles, while no sanitation method was most common in Lomitas. In Lomitas and La Hicaca, water filters were mostly provided via donation by non-governmental organizations. Lomitas had the highest reported incidence of diarrhea among self and other household members.

Conclusions: Critical differences in water access, sanitation, and self-reported diarrheal incidence among three geographically distinct, yet proximal, communities highlights the need for targeted interventions even in geographically proximal rural areas.

Key words: Honduras, sanitation use, self-reported diarrheal incidence, water access.

Introduction

Access to clean water is essential for good health. During the United Nation's (UN) Millennium Summit, state leaders created a set of quantitative targets to be met by the year 2015 that would address several facets of extreme poverty. These targets were coined the Millennium Development Goals (MDGs). The seventh of these goals is to ensure environmental sustainability, and includes halving the proportion of the world's population without access to safe drinking water[1]. Indicators of improved drinking water sources have been defined by the World Health Organization (WHO) and the United Nations Children's Emergency Fund (UNICEF) Joint Monitoring Program (JMP) for Water Supply and Sanitation to include the use of a household connection, public standpipes, boreholes, protected dug wells, protected springs, and rainwater collection. Unimproved drinking water sources include unprotected wells, unprotected springs, rivers or ponds, vendor-provided water, bottled water (due to potential limitations in quantity), and tanker truck water[2,3]. According to a mid-term assessment prepared by the WHO/UNICEF JMP, 83% of the world's population uses improved water sources, and therefore is on track to meeting MDGs[2,4]. Nevertheless, 1 billion people lack access to improved water sources, with most of these individuals living in developing countries[4].

As of 2002, 60% of the population in Latin America was without improved drinking water sources[2]. In Honduras, 87% of the population is using improved drinking water sources, and the country is on course to meet its MDGs[5]. However, this number can be deceiving, especially considering that 95% of urban populations, compared with 79% in the rural setting, are using improved water sources[5]. Furthermore, if it is taken into account that 48% of Hondurans live in rural areas, it becomes clear that a large subset of the population is yet without improved drinking water[6].

The greatest concern related to inadequate drinking water quality is diarrheal illness. According to a study conducted by Black et al, 88% of diarrheal diseases worldwide are attributed to unsafe water, and inadequate sanitation and hygiene[7]. Children are most affected by diarrheal illness. Worldwide, there are an estimated 2.5 billion yearly cases of diarrhea that occur among children under five years of age[8]. With an estimated 1.5 million deaths each year, diarrhea is second only to acute respiratory infections as the leading cause of mortality among this age group[9], and is responsible for 1 in 5 childhood deaths[10].

Although increases in access to oral rehydration therapy have improved in Honduras, diarrheal illness continues to be a concern[11]. In a study by Fischer Walker et al published in 2012, the incidence of diarrheal illness in Honduras for children under five years of age was estimated at 18.6 episodes per child year[12]. WHO data for children under 5 years of age from 2004 indicated that poor water and sanitation contributed to a death rate of 106 per 100 000 capita and 3862 disability adjusted life years per 100 000 capita[13]. Updated data on diarrheal illness in rural areas is lacking.

Since 2005, the nonprofit organization Honduras Outreach Medical Brigada Relief Effort (HOMBRE) has operated health clinics in the communities of Coyoles, La Hicaca, and Lomitas, located within the rural Department of Yoro area of Honduras. These communities are located within three geographically distinct areas about 110 km away from each other. Despite close proximity, health statistics from Coyoles and La Hicaca indicate a disproportionate burden of infectious and chronic diseases[14-16].

Objectives

The purpose of this study was to examine water accessibility and water sanitation behaviors as well as self-reported diarrheal disease incidence among three separate communities in the rural Department of Yoro area of Honduras in order to:

1. Compare and contrast differences in the examined variables among the communities of Coyoles, La Hicaca, and Lomitas.
2. Use these data to develop water sanitation and diarrheal illness relief aid for future medical brigades in the area.

Methods

Participant recruitment

A convenience sample of adults receiving care from a medical brigade in Honduras during the month of June 2011 were invited to participate in a brief, anonymous, interviewer-administered, language-specific water sanitation questionnaire.

Recruitment occurred within the rural Department of Yoro in the towns of Coyoles, La Hicaca, and Lomitas. Coyoles is located near the city of Olanchito. It is accessible via paved roads, and has extensive access to electricity. La Hicaca and Lomitas, which are both located in mountainous regions, are accessible only via dirt roads, and have minimal to no access to electricity. At each site, the medical brigade provided free care to all attendants. An invitation to participate in the study was extended to the brigade attendees while they waited in line to register with the brigade, waited in line for physicians to become available, or immediately following the procurement of all medical care. The invitation was conducted by research personnel and included a brief discussion on the study's purpose, willingness to participate, and an evaluation of eligibility based on inclusion criteria. All participants who were at least 18 years of age or older, fluent in Spanish, and a resident of Honduras were eligible to participate. Participants were then provided with verbal informed consent or a copy of the written consent form if they so desired. It was explained to participants that their decision to participate in this study would not alter their ability to receive medical care from the brigade. Given the high rates of illiteracy in these communities, all questionnaires were administered by research personnel in an interview format. No incentives were granted for completing the questionnaire.

Survey

The water sanitation survey used in this study consisted of 11 multiple-choice questions, with an open-response option for which 'other' was listed as an answer choice. The surveys were translated from English to Spanish, and subsequently back-translated to English to ensure survey validity. Water accessibility was assessed through two questions:

1. Do you have access to more than one source of fresh clean water? (a=yes; b=no).
2. What is your single most common source of water for: drinking, cleaning vegetables, and cleaning food-handling utensils?' (a=river or stream, b=well, c=cistern, d=rain, e=private faucet, f=public faucet, g=water tank truck, h=store-bought bottled water, i=other) with the request to specify source.

As a result of this study, research personnel learned that the Standard Fruit de Honduras Company (formally known as Dole) provides free filtered and chlorinated water to its employees. If the individual obtained water from Standard Fruit on company grounds, then 'Standard Fruit' was listed as their water source. If the individual obtained water from Standard Fruit through a private or public faucet, then private/public faucet was listed as their water source.

Three water collection questions were asked only to individuals who did not identify having a private faucet at home:

1. Gender and age of the individual obtaining the water.
2. Distance traveled (a= <1 km, b=1-5 km, c= >5 km)
3. Mode of transportation used (a=foot, b=car, c=not sure [listed as a transportation method answer choice, but listed as 'other' in the results]).

Water sanitation was explored through four questions. The first question asked for the single most common method used to disinfect water for drinking, cleaning vegetables, and cleaning food-handling utensils (a=boil, b=chlorine, c=filter, d=exposing it to the sun, d=none e=other [specify method]). Individuals were allowed to use 'other' as an option to express the use of multiple sanitation methods. Standard Fruit, municipal water, and bottled water were listed as sanitation methods because participants knowingly used these as a means of specifically obtaining sanitized water. Municipal water was provided through a purchased service that filtered and chlorinated the water. The remaining three questions were asked only if filters and/or chlorine were selected as sanitation methods: (i) Where did you obtain your filter? (a=provided by governmental/non-governmental organization, b=made from household items, c=purchased; (ii) Where did you obtain your chlorine? (a=provided by governmental/non-governmental organization, b=purchased); (iii) What chlorine product do you use? (a=liquid, b=tablet).

Reported diarrheal incidence within the last 30 days was assessed through two yes/no response questions that asked about disease: (i) in self; and (ii) among others living in the same household. Diarrhea was defined as three or more loose stools in a 24 hour period.

Statistical analysis

Descriptive statistics were conducted for all study variables. The three-way chi-square test was used to determine statistical significance among responses across the three sites. The Fisher exact test was used when the expected value of a cell count was less than 5. Analyses were conducted using the Statistical Analysis System 9.3 for Windows (SAS Institute Inc; Cary, NC, USA) and Microsoft Excel 2008 for Mac.

Ethics approval

The institutional review board at Virginia Commonwealth University approved the study protocol (HM13600 VCU Office Of Research Subjects Protection).

Results

A total of 263 surveys were completed: 166 (63%) surveys in the town of Coyoles, 47 (18%) in La Hicaca, and 50 (19%) in Lomitas. Every participant (263/263, 100%) identified having access to more than one source of fresh clean water.

Water sources

The use of private faucets ($p<0.01$), public faucets ($p=0.03$), wells ($p<0.01$), and rivers ($p<0.01$) as sources in the water-use categories of drinking water, and water for cleaning fruits, vegetables, and food-handling utensils were significantly different across the three communities (Table 1). For all the water-use categories, private faucets were used most commonly in Coyoles and La Hicaca, while rivers were used most commonly in Lomitas. The use of purchased bottled water as a source of water for drinking was statistically significant ($p<0.01$) across the three communities, used most commonly in Coyoles (53/166, 32%), but not used in Lomitas (0). Only participants in Coyoles identified Standard Fruit as a water source, where it was used mostly as a source of drinking water (9/166, 5%) ($p=0.08$).

Water collection

The number and gender of individuals traveling in order to obtain water, the distance traveled, and the method of water transportation among the three communities are summarized (Table 2). Thirty-two percent (85/263) of all respondents identified having to travel to obtain water. Of these, 80% (28/35) in Coyoles, 45% (5/11) in La Hicaca, and 85% (33/39) in Lomitas identified traveling less than 1 km ($p<0.02$). Females were most commonly responsible for acquiring the water in Coyoles (29/35, 83%), and were the exclusive collectors of water in La Hicaca (11/11, 100%) and Lomitas (39/39,100%) ($p<0.01$). Travel by foot was the most common transportation method ($p<0.01$) in all communities.

Table 1: Sources of water for drinking, cleaning fruits and vegetables, and cleaning food-handling utensils among adults in the rural communities of Coyoles, La Hicaca, and Lomitas participating in the June 2011 medical brigade (*N*=263)

Water use category	Rural community - *n*/*N* (%)			*P*-value
	Coyoles	La Hicaca	Lomitas	
Drinking water				
Private faucets	104/166 (63)	35/47 (74)	11/50 (22)	<0.01
Public faucets	0/166	2/47 (4)	0/50	0.03
Bottled†	53/166 (32)	2/47 (4)	0/50	<0.01
Standard fruit¶	9/166 (5)	0/47	0/50	0.08
Wells	0/166	6/47 (13)	7/50 (14)	<0.01
Rivers	0/166	2/47 (4)	31/50 (62)	<0.01
Rain	0/166	0/47	1/50 (2)	0.37
Water for cleaning fruits & vegetables				
Private faucets	164/166 (99)	38/47 (81)	10/50 (20)	<0.01
Public faucets	0/166	2/47 (4)	0/50	0.03
Bottled†	1/166 (0.6)	0/47	0/50	1
Standard Fruit¶	1/166 (0.6)	0/47	0/50	1
Wells	0/166	6/47 (13)	4/50 (8)	<0.01
Rivers	0/166	1/47 (2)	35/50 (70)	<0.01
Rain	0/166	0/47	1/50 (2)	0.37
Water for cleaning food-handling utensils				
Private Faucet	165/166 (99)	38/47 (81)	10/50 (20)	<0.01
Public Faucet	0/166	2/47 (4)	0/50	0.03
Bottled†	0/166	0/47	0/50	N/A
Standard Fruit¶	1/166 (0.6)	0/47	0/50	1
Wells	0/166	5/47 (11)	4/50 (8)	<0.01
River	0/166	2/47 (4)	35/50 (70)	<0.01
Rain	0/166	0/47	1/50 (2)	0.37

† Purchased bottled water. ¶ Standard Fruit de Honduras Company provides free filtered and chlorinated water to its employees. The Standard Fruit category was reserved for individuals who obtained water on company grounds. Individuals who obtained water from Standard Fruit through a private or public faucet were counted under that respective category, and not under Standard Fruit.

Table 2: Number and gender of individuals identifying the needed to travel in order to obtain water, distance traveled, and method of water transportation among adults in the rural communities of Coyoles, La Hicaca, and Lomitas participating in the June 2011 medical brigade (*N*=263)

Item	Rural community - *n*/*N* (%)			*P*-value
	Coyoles N (%)	La Hicaca N (%)	Lomitas N (%)	
Individuals needing to travel	35/166 (21)	11/47 (23)	39/50 (78)	<0.01
Gender				
Female	29/35 (83)	11/11 (100)	39/39 (100)	0.01
Male	6/35 (17)	0/11	0/39	0.01
Distance travelled† (km)				
<1	28/35 (80)	5/11 (45)	33/39 (85)	0.02
1-5	6/35 (17)	4/11 (36)	2/39 (5)	0.03
>5	1/35 (3)	2/11 (18)	4/39 (10)	0.19
Transportation method†				
On foot	22/35 (63)	10/11 (91)	39/39 (100)	<0.01
Car	1/35 (3)	1/11 (9)	0/39	0.12
Other	12/35 (34)	0/11	0/39	<0.01

†Only to individuals who identified travelling for water were asked.

Water sanitation methods

The methods used to sanitize water for the water-use categories of drinking water, and water for cleaning fruits, vegetables, and food-handling utensils in Coyoles, La Hicaca, and Lomitas are summarized (Table 3). Only in Coyoles was water from Standard Fruit and a municipal water service available as methods of acquiring sanitized water. The use of no sanitation method for any of the water-use categories was statistically different across the three communities ($p<0.01$), and most common in Lomitas. The use of bottled water as a method of using sanitized water for drinking was most common in Coyoles (48/166, 29%), not used in Lomitas (0/50, 0%), and significantly different ($p<0.01$) across the three communities. The use of filters and chlorine as methods to sanitize water for cleaning fruits, vegetables, and food-handling utensils was significantly different across the three communities and used most commonly in Coyoles.

Filter and chorine obtainment

Self-fabricated filters ($p<0.01$) were used most commonly (59/73, 81%) in Coyoles, and filters donated by governmental and non-governmental organizations (NGOs) ($p<0.01$) were most commonly used in La Hicaca (17/20, 85%) and Lomitas (13/14, 93%) ($p<0.01$) (Table 4). In all three communities chlorine was purchased (59/59, 100%), and obtained only in liquid form (59/59, 100%).

Diarrheal incidence

Self-reported incidence of diarrheal disease ($p<0.03$) was highest in Lomitas (13/50, 26%) and lowest in La Hicaca (3/47, 6%) (Fig1). Reported incidence of diarrheal disease among other household members ($p<0.01$) was highest in Lomitas (23/50, 46%) and lowest in Coyoles (40/166, 24%).

Discussion

This study documented differences in water sources, food-preparation sanitation practice and self-reported diarrheal incidence within the rural department of Yoro between the geographically proximal communities of Coyoles, La Hicaca, and Lomitas. All communities are impoverished and under the auspices of the same local Ministry of Health.

Of the communities surveyed, Coyoles is the least rural. The Standard Fruit de Honduras Company owns and operates many fruit plantations in this area. As the largest employer in the region, the company is responsible for much of the economic growth and development observed in Coyoles[17]. As mentioned previously, Standard Fruit provides free chlorinated and filtered water to employees. The data obtained from this study suggests that private faucets and bottled water are more readily used in Coyoles. Respondents from Coyoles had the lowest rate of reported diarrheal incidence among household members.

Lomitas was the most rural and geographically isolated community surveyed. Respondents from Lomitas were more likely to obtain water from rivers, not use any water sanitation method, not purchase bottled water, and not use sanitized water for cleaning fruits, vegetables, and food-handling utensils. When water sanitation methods were used in Lomitas, filters were almost entirely provided via donation from the government or NGOs, and chlorine, when available, was always purchased. Women traveling on foot almost exclusively performed water collection in Lomitas. Predictably, Lomitas had the highest incidence of both self-reported diarrheal disease and reported diarrheal illness in other household members.

La Hicaca is also located in a mountainous region of Honduras, and about 7 km from Lomitas. Participants from La Hicaca were more likely to report access to a private faucet, and to use chlorine or a filter to sanitize water specifically for drinking. As in Lomitas, filters were almost exclusively donated, while chlorine was purchased. La Hicaca had the lowest self-reported incidence of diarrhea. The HOMBRE brigades have distributed clay-based water filters to the households in La Hicaca since 2008. The use of donated water filters in this community may have had a positive impact on the self-reported diarrheal illnesses rate. It is unclear why this community did not also demonstrate a low incidence of reported diarrheal incidence among other household members, but this may be an artifact of sampling bias.

Table 3: Methods used to sanitize water for drinking, cleaning fruits and vegetables, and cleaning food-handling utensils among adults in the rural communities of Coyoles, La Hicaca, and Lomitas participating in the June 2011 medical brigade (*N*=263)

Water use category	Rural community - *n/N* (%)			*P*-value
	Coyoles	La Hicaca	Lomitas	
Drinking water				
Filter	51/166 (31)	19/47 (40)	14/50 (28)	0.36
Bottled†	48/166 (29)	2/47 (4)	0/50	<0.01
Chlorine	23/166 (14)	9/47 (19)	7/50 (14)	0.66
Municipal¶	38/166 (23)	0/47	0/50	<0.01
Standard Fruit§	46/166 (28)	0/47	0/50	<0.01
Boil	30/166 (18)	1/47 (2)	0/50	<0.01
Sun	2/166 (1)	0/47	0/50	1
No sanitation	3/166 (2)	17/47 (36)	30/50 (60)	<0.01
Sanitation packets‡	1/166 (0.6)	0/47	0/50	1
Water for cleaning fruits and vegetables				
Filter	48/466 (29)	1/47 (2)	2/50 (4)	<0.01
Bottled†	4/166 (2)	0/47	0/50	0.46
Chlorine	29/166 (18)	3/47 (6)	2/50 (4)	0.02
Municipal¶	59/166 (36)	0/47	0/50	<0.01
Standard fruit§	38/166 (23)	0/47	0/50	<0.01
Boil	12/166 (7)	1/47 (2)	0/50	0.07
Sun	1/166 (0.6)	0/47	0/50	1
No sanitation	25/166 (15)	42/47 (89)	46/50 (92)	<0.01
Sanitation packets‡	2/166 (1)	0/47	0/50	1
Water for cleaning food-handling utensils				
Filter	47/166 (28)	1/47 (2)	0/50	<0.01
Bottled†	0/166	43/47 (92)	0/50	<0.01
Chlorine	26/166 (16)	2/47 (4)	0/50	<0.01
Municipal¶	60/166 (36)	0/47	0/50	<0.01
Standard fruit§	39/166 (24)	0/47	0/50	<0.01
Boil	5/166 (3)	1/47 (2)	0/50	0.72
Sun	0/166	0/47	0/50	N/A
No sanitation	30/166 (18)	0/47	50/50 (100)	<0.01
Sanitation packets‡	2/166 (1)	0/47	0/50	1

† Purchased bottled water. ¶Municipal service that provides filtered and chlorinated water as purchased by participant. §Standard Fruit de Honduras Company provides free filtered and chlorinated water to its employees
‡Sanitation packets provided to participants by the local Health Department at no cost.
Note: Individuals were allowed express the use of multiple sanitation methods. Standard Fruit, municipal water, and bottled water were listed as sanitation methods because participants knowingly used them as a means of specifically obtaining sanitized water.

Table 4: Methods of obtaining water filters among adults in the rural communities of Coyoles, La Hicaca, and Lomitas participating in the June 2011 medical brigade (*N*=263)

Item	Rural community - *n/N* (%)			*P*-value
	Coyoles	La Hicaca	Lomitas	
Water filter obtainment method†				
Self-fabricated¶	59/73 (81)	3/20 (15)	1/14 (7)	<0.01
Donation§	2/73 (3)	17/20 (85)	13/14 (93)	<0.01
Purchased	12/73 (16)	0/20	0/14	0.04

†Only participants who identified using filters were asked. ¶Self-fabricated from household items. §Donated by a government or non-government organization

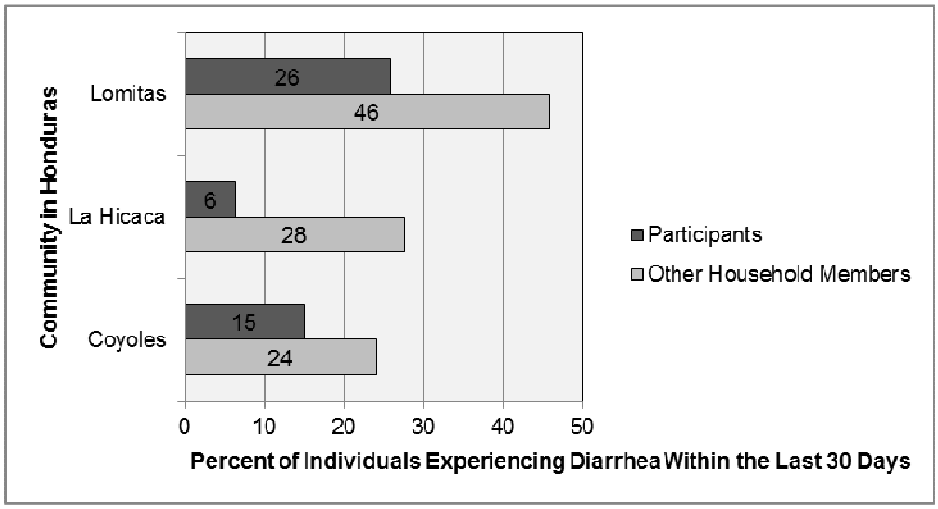

Figure 1: Self-reported diarrheal incidence among survey participants ($p<0.03$) and other household members ($p<0.01$) among adults in the rural communities of Coyoles, La Hicaca, and Lomitas participating in the June 2011 medical brigade ($N=263$).

Given the lack of access to piped and sanitized water in many resource-poor settings, the WHO recommends water treatment at the household level as the best approach to increasing the global availability of sanitized water[18]. Several studies in Latin America have documented an improvement in household water quality and diarrheal incidence through the use of varying water filter types[19-21]. Filter types include[18]:

- granular media rapid rate
- slow sand
- vegetable and animal derived depth
- fabric, paper, membrane or canvas
- ceramic and other porous cast
- septum and body feed.

Success of water sanitation filters is dependent upon several variables. First, water filters must be simple to operate and easy to integrate into daily use. Of note, not all filtration systems reduce loads of certain microbes equally[18]. Due to large pore size, fabric filters are not recommended for the general treatment of household water. Yet, their use is recommended by the WHO for sanitation against guinea worm and for the use in conjunction with other sanitation methods for the improvement of water turbidity and microbial count[18].

The use of filters obtained almost exclusively by donation highlights the need for the continuous provision of such materials by the government and NGOs. Chlorine was most commonly purchased, questioning its realistic use in water sanitation, as the procurement of such a product may not be economically feasible for many families.

Few individuals across the three communities used a sanitation method to disinfect water for cleaning fruits, vegetables, and food handling utensils, as compared to water used for drinking. The ongoing use of unsanitized water for food preparation, despite the availability of water sanitation options, underscores the continued need for educational efforts to focus on raw foods as harbors of diarrhea-causing microbes[22,23] and post-supply deterioration of water due to contaminated containers[24,25]. Persistent knowledge and practice gaps on how to best utilize water both for drinking and food preparation suggest the need for a multi-level approach to improve water safety, since the inconsistent use

of sanitized water will result in ongoing diarrheal illnesses in these communities.

This study adds to the body of literature on water access and related sanitation practices in resource-poor settings. Our findings are consistent with those of other studies that demonstrated the substantial role of women in water collection[26]. For water intervention strategies both globally and in Honduras, this information is of particular relevance, and underscores the need for the involvement of women in the development and maintenance of successful community water projects[27].

Global studies published by the WHO and UNICEF on water access and sanitation have focused on differences between rural and urban areas, but have not primarily addressed differences within proximal rural communities[2,3]. Nuances in healthcare access exist between geographically close and impoverished communities. A study by Pearson et al reported significant differences in healthcare access between Coyoles, Lomitas and La Hicaca, with the most remote community of Lomitas experiencing the greatest burden of barriers[28]. Our study adds to the body of literature on Central American and Honduran health disparities. Even within similar, impoverished communities, unforeseen topographic factors may have a profound impact on a community's access to varying resources. In this case, although the mountainous communities of La Hicaca and Lomitas are only 7 km apart and are under the purview of the same Ministry of Health, significant differences were observed in access and use of sanitized water for drinking and food preparation. These differences may also have had an impact on self-reported diarrheal illnesses. Region-specific information on healthcare and sanitation disparities are of value and may be used to guide relief efforts and resource allocations for health ministries and NGOs.

This study has several strengths. A standardized questionnaire and data collection form was used for all participants. All questionnaires were performed by native Spanish-speaking research personnel, thus minimizing reader misrepresentation and literacy limitations. Study limitations included the use of a convenience sample interview methodology of clinic attendees. As a result, participants may not be representative of the referent population. In addition, data on the water utilization and sanitation practices, along with self-report of diarrheal incidence is subject to recall bias and may have impacted the questionnaire responses.

Conclusions

We observed differences in water sanitation and access in geographically proximal, impoverished rural communities in Honduras. Additionally, self-reported diarrheal illnesses differed across these communities. Short-term medical relief missions focusing on public health interventions, such as water sanitation, should take into account disparities between geographically close communities under the same local health ministry in an attempt to maximize the allocation of services, resources and interventions.

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