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ORIGINAL RESEARCH

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Parasite prevalence in the Palajunoj Valley: Water system case study in Candelaria, Guatemala

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ABSTRACT

Background: Due to poor sanitation and lack of infrastructure in rural Guatemala, diarrheal disease is prevalent. The goal of this paper is to investigate the prevalence of gastrointestinal parasites in children in the Palajunoj Valley and to conduct a case study in Candelaria—a rural Guatemalan community in the Palajunoj Valley—regarding the current state of their water system and household water practices.

Methods: The Primeros Pasos Clinic, a primary care medical and dental clinic in the Palajunoj Valley, collected over 1,000 fecal samples in 2015 from children in the Palajunoj Valley and tested them for parasites presence. Those data were analyzed retroactively. Interviews and water tests were conducted in Candelaria with community leaders and women in the community.

Results: 60.11% of children in the Palajunoj Valley and 50.47% of children in Candelaria presented with at least one type of gastrointestinal parasite. 37 out of 95 houses in Candelaria do not have access to tap water. Unfiltered tap water was highly contaminated with hydrogen peroxide producing bacteria. Boiled water and filtered water presented lower levels of contamination.

Conclusions: The high level of parasite prevalence is at least partially due to lack of access to clean water. The three major issues in Candelaria are lack of infrastructure, financial barriers, and lack of sufficient education surrounding the importance of clean water.

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Introduction

Diarrheal disease in children is a significant cause of mortality around the world. Prevention is primarily focused on increasing access to clean water. Three out of ten people globally lack access to safely managed drinking water services, six out of ten people lack access to safely managed sanitation facilities, and each day almost 1,000 children die due to preventable water and sanitation-related diarrheal diseases [1]. Guatemala's WASH Poverty Diagnostic outlines the causes of the current water crisis in Guatemala. Although Guatemala is a lower-middle income country, The Gini Coefficient for Guatemala in 2014 was 48.3, showing that it is ranked as the 10th country with the highest economic inequality [2,3]. The WHO statistical profile on Guatemala found that in 2013, 7% of the of deaths of children under five years old in Guatemala was due to diarrheal disease, and diarrheal disease is the 7th leading cause of death in Guatemala, killing 3,000 people in 2012 [4]. Geographically and politically isolated communities in Guatemala have poorer health compared to more urban areas [5]. Health disparities in Guatemala disproportionately affect indigenous people, exemplified through worse health outcomes in the indigenous population [6].

Parasite prevalence in Guatemala's Palajunoj Valley was first documented by a study using data obtained by The Primeros Pasos clinic between 2004 and 2007 [7], and this study uses that data as a baseline. The study showed that the five most prevalent parasites and their infection rates were

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Ascaris lumbricoides (17.7%), *Giardia intestinalis* (16.1%), *Entamoeba histolytica* (16.1%), *Hymenolepis nana* (5.4%), and *Blastocystis hominis* (2.8%). There was a higher prevalence of *G. intestinalis* and *E. histolytica* in younger children, *H. nana* in females, and *G. intestinalis* in malnourished children [7].

The goal of this study is to build upon the work done by Cook et al. [7] and analyze 2015 children parasite data from the Palajunoj Valley obtained by the Primeros Pasos Clinic. Then, the paper will present the results of a case study in Candelaria, one of the communities in the Palajunoj Valley, and discuss conclusions made from those results.

Materials and Methods

2015 Parasite Data from the Palajunoj Valley

Staff at the Primeros Pasos clinic visited the primary school in 9 out of the 10 communities in the Palajunoj Valley to collect stool samples from each student and then tested them in their laboratory for the following 10 parasites: *Ascaris lumbricoides*, *Blastoscystis hominis*, *Entamoeba coli*, *Entamoeba histolytica*, *Endolimax nana*, *Giardia intestinalis*, *Hymenolepis nana*, *Iodomeba butschlii*, *Trichomonas hominis*, and *Trichuris trichuira*. Xecaracoj is left out of this study, because there is no parasite data for Xecaracoj in 2015. The Primero Pasos team attempted to collect samples from every primary school age child (up to 12-year old), using methods from a previous study [8], and succeeded in collecting samples from 70% of children registered in primary school in the Palajunoj Valley. Statistical Analyses were performed using MATLAB 2018a. Paired t tests were conducted to compare parasite prevalence in Candelaria to The Palajunoj Valley (Fig. 1), Candelaria to Xepache (Fig. 2), and Candelaria to Llanos de Pinal (Fig. 2).

Candelaria case study

Candelaria was chosen as a focus for research on water usage, sanitation, and infrastructure because of interest from community leaders in implementing an improved clean water plan in the community. Anonymous interviews were carried out in January 2019. The community leaders and women in the community were spoken to in this study. See Appendix for a list of questions participants were asked. In addition, Water tests were performed using the Patho Screen™ Medium water testing procedure (Hach Company). Data were analyzed in February 2019. IRB approval was obtained from Vanderbilt University.

Results

2015 parasite data from the Palajunoj Valley

The data obtained from the laboratory of the Primeros Pasos clinic show that 60.11% of the children tested in the Palajunoj Valley are infected with gastrointestinal parasites. The communities with the highest percentage of children infected with parasites are Las Majadas and Bella Vista with 79.75% and 73.74% infection rates, respectively. Chuicaracoj has the smallest percentage of infected children at 31.25% (Table 1). Children who presented more than one type of parasite were included multiple times in Table 2. The most common parasites in the Palajunoj Valleys were *B. hominis*, *A. lumbricoides*, *E. nana*, *G. intestinalis*, and *E. histolytica,* and the five most common parasites in Candelaria were *B. hominis*, *E. coli*, *E. nana*, *E. histolytica*, and *G. intestinalis.* There was no significant difference in the parasite prevalence in Candelaria compared to the rest of the Palajunoj Valley (p = 1.00) (Fig. 1), Candelaria compared to Xepache (p = 1.00) (Fig. 2), and Candelaria compared to Llanos de Pinal (p = 1.00)(Fig. 2).

Candelaria case study

The water system in Candelaria was put in place approximately 20 years ago by the Municipality of Quetzaltenango. The water supply is controlled by the Municipality from the public well located in the adjacent community of Llanos de Pinal, which leads to the storage tank in Candelaria. This well serves four communities: Llanos de Pinal, Candelaria, Xecaracoj, and Xepache. There is a communal tap at the entrance to Candelaria that is open for use. There is no water drainage or sewage system in Candelaria. Community leaders estimate there to currently be four or five breaks in the water system. It has been 2 or 3 years since the Municipality has cleaned the storage tank in Candelaria. Families who have been in the community for over 50 years pay Q14 (quetzals) per month per house for access to water and electricity. Families who have been in the community for less than 50 years pay Q28 per month per house for access to water and electricity. There are 25 new houses being constructed in addition to the 95 current houses.

All households use either collected rainwater, unfiltered tap water from the house or communal tap to shower, wash clothes, and wash animals. In 2017, Primeros Pasos donated Ecofiltros to 12 households who were participating in the nutrition outreach program; the primary school purchased

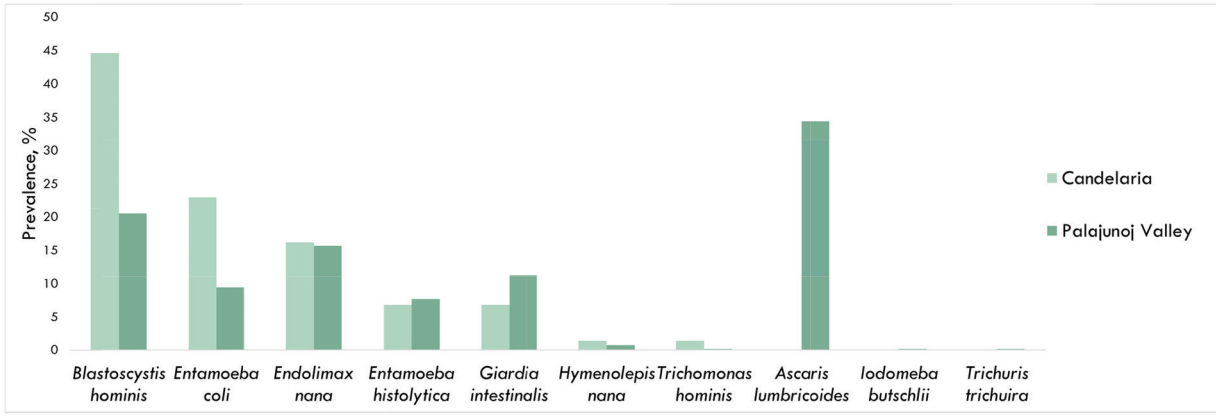

Figure 1. Distribution of parasites in Candelaria and the Palajunoj Valley. Percent prevalence indicates number of incidences of that specific parasite/total number of incidences across all parasites.

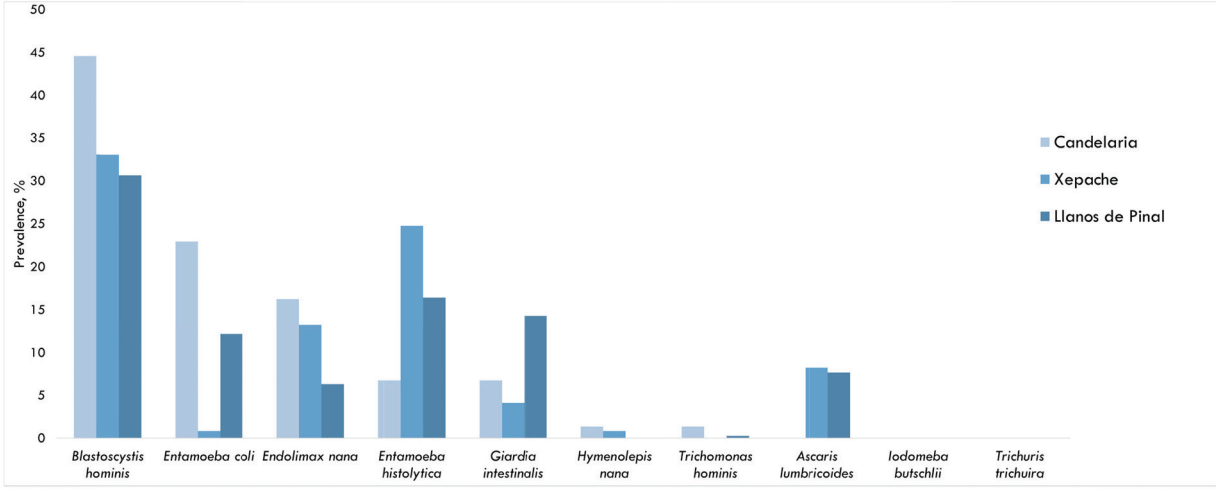

Figure 2. Distribution of parasites in Candelaria, Xepache, and Llanos de Pinal. Percent prevalence indicates number of incidences of that specific parasite/total number of incidences across all parasites.

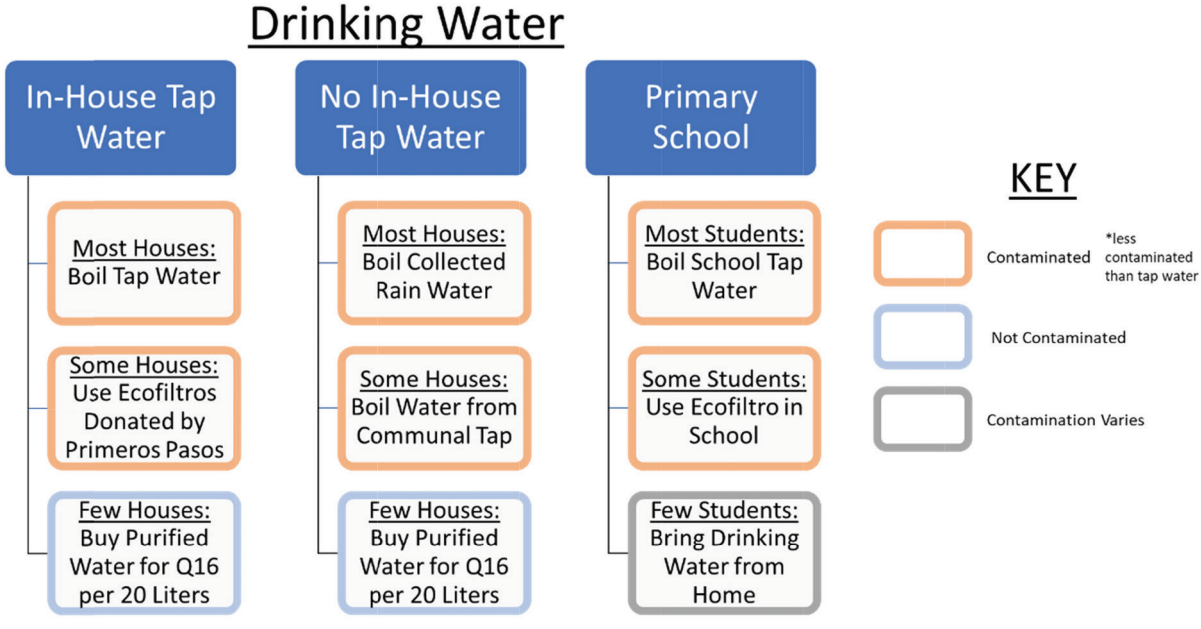

Figure 3. Indication of the drinking water practices among community members in Candelaria with respect to how common each practice it. The contamination levels are indicated for each drinking water practice.

Table 1. Percentage of children infected with parasites in each community.

Community	Infected samples	Not Infected samples	Samples that could not be tested	Total number of samples	Percentage of children infected with parasites
Las Majadas	193	47	2	242	79.75%
Bella Vista	73	26	0	99	73.74%
Tierra Colorada Alta	73	36	0	109	66.97%
Chuicavioc	180	89	0	269	66.91%
Xepache	92	58	3	153	60.13%
Tierra Colorada Baja	113	83	1	197	57.36%
Candelaria	54	53	0	107	50.47%
Llanos del Pinal	275	290	3	568	48.42%
Chuicaracoj	5	10	1	16	31.25%
Total	1058	692	10	1760	60.11%

their own Ecofiltro, funded by the Ministry of Education. Each Ecofiltro costs Q300, and the system's filter must be replaced every 2 years for Q200. The filter requires monthly cleaning.

Discussion

2015 parasite data from the Palajunoj Valley

This study showed a decrease in the prevalence of *A. lumbricoides, G. intestinalis*, and *B. hominis* compared to the Cook et al. [7] study that analyzed similar data from Primeros Pasos in 2004–2007 (Table 4). Here, we showed an increase in the prevalence of *E. histolytica* and *H. nana* (Table 4).

Las Majadas and Bella Vista have the highest prevalence of parasites and also are the communities furthest from the city of Quetzaltenango and the Primeros Pasos clinic. This high level of infection is most likely due to inaccessibility to health services, transportation, and clean water due to the remote location of these communities. The most common parasites in Candelaria are similar to the rest of the valley, indicating that the causes of contamination similar across the valley (Fig. 1). In addition, the similar parasite prevalence in Candelaria, Xepache, and Llanos de Pinal may indicate source contamination because these three communities share a common water source (Fig. 2).

Table 5 presents whether each parasite is a helminth or protozoan and if it has pathogenic effects in humans [9–14]. Five parasites are pathogenic, three of which are helminths and two of which are protozoa. Protozoa are single celled organisms that can be free living or in human hosts, where they multiply. Intestinal protozoa are normally transmitted via the fecal-oral route through contaminated food or water or personal-to-person contact. Blood-borne protozoa are generally transmitted through arthropod vectors [9]. Helminths are larger, multicellular organisms that are usually visible to the human eye. They can be free living in aquatic or terrestrial environments or live within a host organism. The adult form of helminths cannot multiply like protozoa [9]. It is important to note that the commensal protozoa do not create harmful side effects to their human hosts. The most common pathogenic parasites in Candelaria are *E. histolytica* and *G. intestinalis*, so treatment and prevention efforts should be focused on those parasitic infections.

Candelaria case study

The cause of diarrheal illnesses in Candelaria is multi-faceted. The first issue is that all the houses do not have tap water. This is an infrastructural issue that can be fixed with a large-scale infrastructure project, but it would require support from the Municipality of Quetzaltenango. The second issue is the financial barrier to access clean water. The Q28 per month that most families pay for tap water and the Q16 per liter of purified water are very expensive for the community members. The third issue is that some members of the community do not perceive clean water to be a priority for them; therefore, there needs to be increased education about the importance of clean water. There also must be a way to promote constant maintenance of the Ecofiltros.

Table 2. Incidence of each parasite in each community.

	Blastocystis hominis	*Ascaris lumbricoides*	*Endolimax nana*	*Giardia intestinalis*	*Entamoeba coli*	*Entamoeba histolytica*	*Hymenolepis nana*	*Iodomeba butschlii*	*Trichomonas hominis*	*Trichuris trichuira*	Total
Llanos del Pinal	116	29	62	54	24	46	0	0	1	0	332
Las Majadas	54	116	38	1	12	16	0	0	0	2	239
Chuicavioc	102	32	26	39	8	10	1	1	0	0	219
Tierra Colorada Baja	55	13	19	27	15	12	0	0	0	0	141
Xepache	40	10	30	5	16	1	1	0	0	0	103
Bella Vista	11	57	9	2	16	3	4	0	0	0	102
Tierra Colorada Alta	34	11	6	14	14	6	2	1	0	0	88
Candelaria	33	0	12	5	17	5	1	0	1	0	74
Chuicaracoj	3	0	2	0	0	0	0	0	0	0	5
Total	448	268	204	147	122	99	9	2	2	2	**1303**

Table 3. Household access to tap water, pit latrines, and garbage disposal systems.

	Households with access	Households without access
Tap Water	58	37
Pit Latrines	70	25
Garbage Disposal Systems	76	19

Table 4. Comparison of infection rates in the Palajunoj Valley with Cook et al. [7].

	Percent of children infected	
	2015 Data	2004–2007 Data [Cook et al.]
Ascaris lumbricoides	20.57	17.7
Entamoeba histolytica	7.60	16.1
Giardia intestinalis	11.28	10.9
Hymenolepis nana	0.69	5.4
Blastoscystis hominis	34.38	2.8
Endolimax nana	15.66	Not Tested
Entamoeba coli	9.36	Not Tested
Iodomeba butschlii	0.15	Not Tested
Trichomonas hominis	0.15	Not Tested
Trichuris trichuira	0.15	Not Tested

Table 5. Characteristics of parasites.

	Type of Parasite	Pathogenicity
Ascaris lumbricoides	Helminth	Pathogenic
Hymenolepis nana	Helminth	Pathogenic
Trichuris trichuira	Helminth	Pathogenic
Entamoeba histolytica	Protozoan	Pathogenic
Giardia intestinalis	Protozoan	Pathogenic
Blastoscystis hominis	Protozoan	Commensal
Endolimax nana	Protozoan	Commensal
Entamoeba coli	Protozoan	Commensal
Iodomeba butschlii	Protozoan	Commensal
Trichomonas hominis	Protozoan	Commensal

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APPENDIX

Questions for Community Leaders

- When was the current water system put in and by whom?
- How does maintenance work?
- Who is in charge of fixing the system?
- Do the all the residents pay for clean water, if so, how much?

Questions for Community Members

Natural Water Sources

- Do you collect rain water or water from natural sources or a creek?
- What do you use this water for?
  - » To bathe? Boil food? Washing hands? Washing clothes?
- Do you purify this water in any way such as boiling water or chlorination?

Tap Water

- What do you use tap water at home for?
  - » To bathe? Boil food? Washing hands?
- Do you purify your tap water in any way such as boiling water or chlorination?
- Do you pay for the water that you use in your homes?
  - » If so, how much? How do you feel about that fee? Is it considered to be affordable or expensive?
- Is tap water always available in your homes?
  - » Or does your tap ever run dry? Or do they ever turn it off?
- Does someone maintain your water source and how reliable is that maintenance?
- Do you know of any broken pipes or leaks in the system? Do you know if your spigot, or anyone else's spigot leaks or is broken?

Purified Bottled Water:

- Do you buy purified water?
- How much do you pay for it per unit and per week?
- Would you be open to going to the school to retrieve water each day?
- What cost would you pay per 20-liter bottle of drinkable water available for purchase at a central location in the village?

What cost would you pay per 20-liter bottle of drinkable water delivered to your home?