2014 Health Demographics of a Rural Nicaraguan Community

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Abstract

In December 2014, a team of church members and associated healthcare workers from Owasso First Assembly in Owasso, Oklahoma, provided a free, two-day clinic and health assessment to the rural community of La Ceiba Dudu in Nicaragua. Services included medical exams, basic medications, dental extractions, and over the counter reading glasses. This report is a retrospective review of the patient records documented at that clinic. We analyzed the prevalence of parasites across five age cohorts and searched for correlations between parasite diagnosis and various patient metrics, including BMI, age, and gender. We searched for a relationship between occupants per household and the number of medical diagnoses and the average blood pressure of each occupant. We searched for a correlation between parasite diagnosis and gastroesophageal reflux, infection, allergies, and arthritis diagnoses. The study lacked power and thus the ability to decisively detect correlations at the $\alpha=0.05$ significance level. However, average blood pressure correlated inversely to the number of occupants in the patient's household ($p=0.06$), and parasite diagnosis correlated marginally with decreased BMI ($p=0.07$).

Introduction

Geographical and Economic Context of Nicaragua

Nicaragua is a Central American country that is bordered by Honduras on its north and Costa Rica on the south. Nicaragua is considered a developing country because it relies heavily on foreign aid (Britannica 2020). The nation has a struggling economy dependent on sugar cane, coffee, maize, rice, palm oil, and other exports. Several trends in Nicaraguan demographics can be compared. According to a survey in 2001, the population was approximately 3.8 million, which showed a substantial increase in twenty-five years from 1.8 million. The average life expectancy was 63.9 years, ten years more than the average in 1965 (Nicaragua 2001).

Cultural habits of a population can help researchers discover the source of significant health challenges. One aspect of cultures and communities across the world that researchers are able to analyze is non-communicable disease (Laux et al. 2012). Some of these diseases are "problematic" and are a primary cause of death throughout diverse cultures. Therefore, researchers study the demographics of a society and look at socioeconomic factors, such as the number of impoverished communities, access to and affordability of healthcare, and major categories of employment.

Nicaraguans suffer from chronic conditions, including cardiovascular disease, respiratory disease, and diabetes, as well as obesity (Laux et al. 2012). One study of six communities found that more men than women consumed tobacco and alcohol. Interestingly, for women, higher economic status correlates with obesity (Laux et al. 2012).

Aftermath of Sandinista Revolution

The Sandinista revolution of the 1970s and 1980s was a dramatic period for Nicaragua. It crippled the economy and destroyed the structure of the country, which led to lasting consequences. In 1979, the Sandinistas overthrew President Anastasio Somoza Debayle, whose family had been dictators for decades (Britannica 2020). The Sandinistas then ruled Nicaragua from 1979-1990. During the revolutions, the government had bloody retaliations to Sandinista efforts. The Sandinistas were challenged by the Contras, which were the counter-revolutionists. The Contras were established in Honduras and financially supported by the U.S. government. Conversely, the Sandinistas were dependent on the Soviet Union and Cuba (Britannica 2020).

The conflict put many Nicaraguan citizens in poverty and caused the loss of thousands of lives. The strain on the country also had a significant impact on the position of women in society. After the Sandinistas lost the 1990 elections, Nicaragua was forced to rebuild their society. Foreign countries had major involvement in the fate of Nicaragua while the people paid the price of civil war. The economic status of Nicaragua was largely dependent on agrarian exports. Wealthier families sent their children to the United States for education, while children from lower-income families did not receive higher education (Zaremba 1992). Apparently, the government intended that a large population would remain uneducated in order to provide a constant supply of agrarian workers (Zaremba 1992).

Healthcare in Nicaragua

It has proved difficult to collect complete and accurate data about the Nicaraguan population. One case study created a basis for taking surveys and collecting statistical data (Pena et al. 2008). Public health is a major problem in many Nicaraguan cities and towns. A suggested solution to this problem is to first determine how to analyze problems and then create solutions based on the resources and financial states of the country (Pena et al. 2008). An in-depth analysis of a healthcare system in a population is vital. General surveys without detail will provide inaccurate results which lead to the unavailability of medicine to cities in great need. Therefore, before researchers and doctors can develop a sustainable healthcare system for Nicaraguan communities, an accurate assessment must be developed. Creating a foundation of research and diagnoses will allow the introduction of modern medicine.

A specific complication arose in a study about the collision of cultural practices in medicine. In one specific case, conflict between western medicine and indigenous medicine was uncovered (Carrie et al. 2015). Such conflict is not seen in every Latin American country, but evident in Nicaragua due to its failure to keep current in medical practices. Researchers have concluded that new technology is best introduced with a clear initiation process. Nicaraguan legislators created laws to try and facilitate such a transition. Tense relationships were present between western doctors and native healers, due to a lack of respect on both sides (Carrie et al. 2015). The dynamic of mistrust and lack of resources for healthcare is the background against which modern medical missions trips are planned and executed.

Complications of bringing healthcare to Nicaragua are more than just clashes of medicinal practices. Political corruption has had an effect on healthcare operations, disrupting an efficient treatment system (Agren 2018). Corruption further prevents help from reaching rural and remote areas. Certain populations, even with access to healthcare, simply cannot afford to pay low costs. Rural areas with low-income have limited access to necessary treatment for their ailments, both acute and chronic (Prado et al. 2016). Even when residents had the opportunity to see physicians, most of them barely had the financial ability to receive proper care.

Parasites in Latin American Communities

Parasites are an ongoing health concern in central America, and they affect quality of life for millions of people. High prevalence of parasitic infections reflects lack of medication and healthcare, poor nutrition, and lack of access to clean water. A study done in 2017 found the major problem in parasitic outbreaks in Latin America was clean water (Rosado-Garcia 2017). Researchers believed contaminated water was the source of the protozoan parasites that infected people. Data about parasitic infections is often inaccurate in developing countries, due to insufficient testing. Parasitic outbreaks appear to be associated with such factors as demographics, climate, and the financial state of the country (Rosado-Garcia 2017).

The prevalence of parasites in Nicaragua has also been shown to be connected to population density and waste disposal (Tellez et al. 1997). The examination of living conditions revealed that those who lived in good housing conditions had a significantly lower rate of intestinal parasites. The authors concluded that households need to use more efficient processes disposing of wastes in order to combat the problem (Tellez et al. 1997).

Entamoeba histolytica is a protozoan that is a disease that is the second leading parasitic cause of death across the globe (Manna et al. 2020). It is prevalent in many developing countries, especially those with poor quality food and water. *E. histolytica*, like many other parasites, is commonly spread through contaminated water, and it resides in the human intestines and other organs (Manna et al. 2020).

Entamoeba histolytica has an active stage and a dormant stage in its life cycle (Manna et al. 2020). The dormant stage allows for it to survive in its environment and transfer to other hosts and reservoirs. Researchers studied the infectious cycle of this parasite to better develop medication to battle against it. However, developing a resistance to antibiotics has led to complications of disease treatment (Vique-Sánchez, 2020).

The infectious cycle begins with the consumption of a cyst of *E. histolytica* (Manna et al. 2020). The bacteria then exits the cyst in the small intestines and begins generating the trophozoite form, which is the disease-causing form of the parasite (Manna et al. 2020). The trophozoite is detected in testing for a definitive diagnosis of amoebiasis (Loftus 2005). Amoebiasis occurs when the parasite secretes proteases that directly kill cells in the mucosa (Stanley 2003). Trophozoites travel past the mucosal barrier and cause amoebic colitis. Symptoms of this disease include but are not limited to bloody diarrhea and abdominal pain. Most patients are asymptomatic but due to recurrent exposure and consumption of contaminated food and water, symptoms can appear and become problematic. About 4-10% of people who lacked symptoms developed the disease over the following year (Stanley 2003).

Another common intestinal parasite is *Giardia lamblia*. *G. lamblia* is the responsible for giardiasis, which causes diarrhea (Gardner & Hill 2001). *Giardia* is found in soil where fecal matter is present. Feces can contaminate food and water sources, which allows *Giardia* to spread to its hosts (Adam 2001). These parasites have cysts forms that allow them to survive in harsh environments. They exit the cyst in the intestine and release two trophozoites which then attach to the mucosa in the intestine and cause infections (Adam 2001).

Metronidazole is a common medication used for protozoan infections. It is derived from nitroimidazole. It is used for *E. histolytica*, *G. lamblia*, and *T. vaginalis* (Freeman et al. 2012). It diffuses into cells easily and can access the central nervous system too. It can be used against anaerobic infections and is said to have little effect on normal microflora in the intestines, therefore it is considered the primary choice by physicians (Freeman et al. 2012). Another medication used is nitazoxanide, which is derived from the class of thiazolidine drugs and used to fight anaerobic bacteria and parasites.

Hypertension

Hypertension is not limited to a particular country or culture. Blood pressure greater than 140 mm Hg for systolic and 90 diastolic is considered high. A study of Nicaraguan coffee farm workers found that nearly 40% of adults were hypertensive (Alicea-Planas et al. 2016). Since high-income countries have a lower prevalence of hypertension than low-income countries, this study was conducted to compare Nicaragua to countries of higher economic status. A lower prevalence of hypertension was found in the Nicaraguans than what was expected, with predictions based on economic status, but many of the people were considered to at least have prehypertension falling in the range of 120-139 mm Hg for systolic and 80-89 mm Hg for diastolic. This report provided information about what to focus on for prevention and treatment efforts (Alicea-Planas et al. 2016).

Hypertension is an important topic for researchers because it is a major causative factor of cardiovascular disease (CVD). CVD is a leading cause of death worldwide. Hypertension is often idiopathic, but known etiologies include genetic predisposition, excess intake of salt or potassium, and environmental stimuli (Staessen et al. 2003). These factors are taken into consideration by researchers in order for them to develop a prevention plan for communities based on healthcare and demographics. Preventative measurements can be made while an increase of awareness is just as important (Valladares et al. 2019).

Eye Care in Impoverished Communities

Eye care holds a lower priority in healthcare than to infectious diseases and other lethal health problems, but it is important. In order to increase the affordability and availability of eye care, governments should make it a priority and fund medical interests that focus on eye care (Schwab 1994). There has been an increase in need for medical missions to countries who lack eye care. Since many communities are not receiving governmental support, they depend on international efforts for help (Murthy et al. 2012).

There are many obstacles to providing eye care in some developing countries. One study showed that the cost of delivery, treatment, glasses, and other optical appliances prevent impoverished communities from affordable eye care (Kyndt 2001). Families may not be able to travel to an access point, because they cannot afford to lose one day's work. Therefore, families need near access to eye care, to prevent financial loss. Failure to treat some conditions, such as glaucoma, can lead to increasing vision loss (Kyndt 2001).

The purpose of our study was to analyze the medical records of 262 rural Nicaraguans that were presented to a two-day clinic in the town La Ceiba Dudu, in December, 2014. We searched for patterns in the presentation of illness, such as significant correlations between several health factors, including but not limited to blood pressure, allergies, parasites, and gastroesophageal reflux disease (GERD).

Materials and Methods

A team of nine church members and associated medical professionals sponsored by Owasso First Assembly in Owasso, Oklahoma traveled to La Ceiba Dudu, Nicaragua, a small, rural northwestern community (Figure 1). The clinic took place December 8-9, 2014, in the local Assembly of God church building, Casa de Dios, Iglesia al Paraiso. The physician was Dr. Stan Grogg, DO, retired attending pediatrician at the Oklahoma State University Center for Health Sciences and College of Osteopathic Medicine (OSUCHS), and his wife, Barbara Grogg, APRN, a nurse practitioner. Also seeing patients were two, fourth-year medical students from OSUCHS, Michael Dunlap and Rachael Hayden.

Figure 1: Map of Nicaragua, red arrow region refers to La Ceiba Dudu

The People of La Ceiba Dudu

The people of La Ceiba Dudu are uniformly Hispanic in race. The average agrarian worker earns the equivalent of about $3/day. A typical home is 200-400 sq ft, made of wood planks, and has a dirt floor (Figure 2).

Figure 2: Most indoor areas include rooms with dirt floors and wooden planks for walls.

Mission Goal

The goal of this mission was to assess the health needs of the population of La Ceiba Dudu. The two-day clinic was held as a scouting event in December of 2014. People were served on a "first come first served" basis and stood in line outside the church (Figure 3). The ultimate goal was to establish a permanent facility and employ a doctor and nurse, which was achieved in December 2016 when the Clinical Medica Piedad, "Mercy Medical Clinic', was officially opened (Figure 4). Its first structure was built by "Clinic in a Can" in Wichita, Kansas, and included a fully equipped modern exam room inside an eight by twenty foot shipping container that runs on power from a diesel generator or solar panels (Figure 5). Clinica Medica Piedad now has several buildings as part of its physical plant and employs a physician, a nurse, a medical technician, and security and cleaning staff.

Figure 3: Civilians gathering on the first day of the temporary clinic.

Figure 4: In August of 2014 the permanent clinic was established. This structure was provided by Clinic in a Can and shipped from Wichita, Kansas.

Figure 5: Inside view of the permanent clinic.

Clinic Days

Patients attended the free clinic for assessment of both acute and chronic illnesses. A translator was present during assessment. Diagnoses were made by listening to patient symptoms and looking for signs with the availability of pregnancy tests when necessary. Based on signs and symptoms as well as tests performed, medical professionals were able to make diagnoses then prescribe basic medications.

Medications

Medical staff came equipped with 30 different medications (Table 1). A temporary pharmacy was set up and organized using plastic, over-the-door, clear, shoe holders (Figure 6). Patient examine rooms were created using shower curtains hung with rope in the local church building. The makeshift rooms allowed the patients a measure of privacy with available space and material (Figure 7).

Table 1 List of Medications Prescribed

	Medication	*Description*
1	Acetaminophen	Analgesic/antipyretic
2	Albendazole	Antihelmintic
3	Algestone	Contraceptive
4	Amoxicillin	Penicillin antibiotic
5	Antifungal cream	Treat fungal infections on skin, scalp, and nails
6	Aspirin	Analgesic/antipyretic/blood thinner
7	Bactrim DS	Antibiotic
8	Calcium carbonate	Antacid
9	Cetirizine hydrochloride	Antihistamine
10	Cough drops	Throat analgesic
11	Dextromethorphan	Cough suppressant
12	Diflucan	Antifungal medicine
13	Diphenhydramine	Antihistamine
14	Fluconazole	Antifungal
15	Gabapentin	Anticonvulsant
16	Gentamycin injection	Aminoglycoside
17	Hydrocortisone cream	Topical corticosteroid to reduce swelling, itching, and irritation
18	Ibuprofen	Anti-inflammatory NSAID
19	IM Rocephin	Injected cephalosporin antibiotic
20	Iron	Supplement for iron deficiency anemia
21	Lamisil	Antifungal;
22	Mebendazole	Antiparasitic
23	Metronidazole	Nitroimidazole
24	Multivitamin	Vitamin supplement for deficiency
25	Mupirocin	Sulfonamide antibiotic
26	Permethrin	Pyrethrin
27	Prednisone cream	Corticosteroid
28	Rehydration powder	Solution of glucose, water, sodium, potassium, and other electrolytes
29	Rocephin	Cephalosporin antibiotic
30	Tylenol	Analgesic/antipyretic
31	Zithromax	Macrolide-type antibiotic

Figure 6: Makeshift pharmacy utilizing plastic shoe holders to organize medications.

Figure 7: Patient examining rooms at the temporary clinic included shower curtains hung with rope in the local church building.

Diagnostic Methodology

Patients were assessed using a diagnostic sheet that allowed for the medical professional to record a proper diagnosis with a plan of action (Figure 8). This data sheet included first and last name, sex, age, and birthday. Patients were also asked if they could read, their occupation, the last time they saw the doctor, if they had chronic health problems and the number of cohabitants in their household. Blood pressure, pulse, height, and weight were also noted. Chief complaints, labeled “cc” on the intake form, were recorded according to the patients, and findings were recorded by the medical professional who assessed them. Limited labs that were available for the clinic included urine analysis, pregnancy tests, and blood sugar testing. If performed, they were recorded on the same diagnostic sheet.

With the provided information, medical professionals recorded diagnoses based on their medicinal knowledge, which was labeled "DX" on the diagnostic sheet. Once diagnoses were made, a plan was formulated for recovery. A space was provided on the diagnostic sheet for osteopathic manipulative medicine if needed. Following the guidance of the sheet, follow up visits and referrals were listed. Finally, medications were prescribed and recorded with the doctor's signature along with the supervising doctor's initials to show approval of the diagnoses, plan of action, and medication prescriptions (Figure 8).

___________________________ M F Age______ Birthdate__________

Name

Read Y N Occupation ____________________ Last time saw a Dr? ____________________________

Where do you go to see a dr? ______________________ #/ages children _______________________________

How many live in your home? ____

If child, Immun. Status? ____

Chronic health problems? ____

Take or supposed to take meds? Y N What med? ____

Ht ______ Wt ______ BMI ______

CC: 1) 2) 3)

FINDINGS: ____

____.

____.

LAB: UA ___________________________ PG TEST ____ BS ______

DX:

1)

2)

3)

PLAN ____

____.

OMM ____

NEEDS FOLLOW UP/REFERRAL: EXPLAIN FULLY including how soon

____

____

____.

PHARMACY: IF MED IS PILL OR CAPSULT – COMPLETE WHO MED BAG EXCEPT VITAMINS

MED ORDERED

Dr. ordering ____________________________

Figure 8: Intake form used at the temporary clinic.

Vision and Dental Diagnoses

Patients who desired reading glasses were allowed to peruse the available prescriptions and select the one they preferred, much as people do in the United States when purchasing "readers" over the counter (Figure 9). Extractions for severe dental caries were also available at the clinic. These extractions were done by a Nicaraguan dentist who joined the group. A standard injection of Novocain (procaine) was provided for pain control. Adequate lighting was provided by a volunteer holding a flashlight near the mouth area (figure 10). Dental records included only the patient's name and number of extractions performed.

Figure 9: Reading glasses were provided free of charge to those that needed them.

Figure 10: Dental extractions were performed using extraction forceps and a flashlight.

Statistical Analysis Methods

Researchers employed a two-tailed t-test to compare the average age of the parasitic population to the average age of the non-parasitic population and performed one-tailed t-tests to analyze the height and BMI of parasitic and non-parasitic populations. This decision was made because prior research by Caspia et al. (2006) indicated that exposure to parasites might stunt growth. Chi-square tests were employed in search for a correlation between parasite diagnoses and other diagnoses: arthritis, gastroesophageal reflux, general infection, fungal infection, and allergies. Finally, linear regression tests were used to determine the correlation between occupants per household and number of diagnoses as well as occupants per household and blood pressure.

Results

We analyzed patient diagnoses, occupants per household, height, body mass index (BMI), and age according to multiple parameters. We segregated the results into four sections: two-sample independent t-test, chi-square, logistic regression, and diagnosis alleviation.

Two Sample Independent T-Test

We compared the mean age of patients diagnosed with parasites to the mean age of patients not diagnosed with parasites (H_0: $\mu_{\text{Age parasitic population}} = \mu_{\text{Age non-parasitic population}}$, H_1: $\mu_{\text{Age parasitic population}} \neq \mu_{\text{Age non-parasitic population}}$) (Table 2). The mean age of the parasitic population was 25.56 years (N=65). The mean age of the non-parasitic population was 29.70 years (N=188). Two-tailed t-test: p=0.20.

We compared the mean height of patients diagnosed with parasites to patients not diagnosed with parasites (H_0: $\mu_{\text{Height parasitic population}} = \mu_{\text{Height non-parasitic population}}$, H_1: $\mu_{\text{Height parasitic population}} \neq \mu_{\text{Height non-parasitic population}}$) (Table 3). The mean height of the parasitic population was 55.58 inches (N=40). The mean height of the non-parasitic population was 57.10 inches (N=128). One-tailed t-test: p=0.18.

We compared the mean BMI of patients diagnosed with parasites to patients not diagnosed with parasites (H_0: $\mu_{\text{BMI parasitic population}} = \mu_{\text{BMI non-parasitic population}}$, H_1: $\mu_{\text{BMI parasitic population}} \neq \mu_{\text{BMI non-parasitic population}}$) (Table 4). The mean BMI of the parasitic population was 21.58 $\frac{kg}{m^2}$ (N=40); the mean BMI of the non-parasitic population was 22.98 $\frac{kg}{m^2}$ (N=127). One-tailed t-test: p=0.07.

Table 2 Age comparison of patients with and without parasites

Statistic	*Parasitic Population*	*Non-parasitic Population*
Mean	25.56	29.70
Variance	475.43	511.68
Observations	65	188
Pooled Variance	502.43	
Hypothesized Mean Difference	0	
df	251.00	
t Stat	-1.29	
P(T<=t) one-tail	0.10	
t Critical one-tail	1.65	
P(T<=t) two-tail	0.20	
t Critical two-tail	1.97	

Table 3 Height comparison of patients with and without parasites

Statistic	*Parasitic Population*	*Non-parasitic Population*
Mean	55.58	57.10
Variance	95.81	76.52
Observations	40	128
Pooled Variance	81.05	
Hypothesized Mean Difference	0	
df	166.00	
t Stat	-0.93	
P(T<=t) one-tail	0.18	
t Critical one-tail	1.65	
P(T<=t) two-tail	0.35	
t Critical two-tail	1.97	

Table 4 BMI comparison of patients with and without parasites

Statistic	*Parasitic Population*	*Non-parasitic Population*
Mean	21.58	22.98
Variance	27.20	27.60
Observations	40	127
Pooled Variance	27.50	
Hypothesized Mean Difference	0	
df	165	
t Stat	-1.47	
P(T<=t) one-tail	0.07	
t Critical one-tail	1.65	
P(T<=t) two-tail	0.14	
t Critical two-tail	1.97	

Chi-Square

We searched for a correlation between parasite diagnoses and gastroesophageal reflux (GER) diagnoses (Table 5). The GER group with parasites had fewer (but not significant) diagnoses than expected, $p=0.134$ ($N=261$).

We searched for a correlation between parasite diagnoses and infection diagnoses (Table 6). The infection diagnosis group with parasites had fewer (but not significant) diagnoses than expected, p=0.280 (N=261).

We searched for a correlation between parasite diagnoses and fungal infection diagnoses (Table 7). The fungal infection group with parasites had the expected number of diagnoses, p=0.715 (N=261).

We searched for a correlation between parasite diagnoses and allergy diagnoses (Table 8). The allergy group with parasites had more (but not significant) diagnoses than expected, p=0.214 (N=261).

We searched for a correlation between parasite diagnoses and gender (Table 9). Women had more (but not significant) diagnoses than expected, p=0.401 (N=241).

Table 5 Analysis of the relationship between parasite and GER diagnoses

Statistic	*Parasitic and GER*	*Parasitic and No GER*	*Non-parasitic and GER*	*Non-parasitic and No GER*
Observed Occurrence	8	59	39	155
Theoretical Occurrence	12.07	54.93	34.93	159.07
Chi Square Value	2.25			
P-value	0.134			

Table 6 Analysis of the relationship between parasite and infection diagnoses

Statistic	*Parasitic and Infection*	*Parasitic and No Infection*	*Non-parasitic and Infection*	*Non-parasitic and No Infection*
Observed Occurrence	18	49	66	128
Theoretical Occurrence	21.56	45.44	62.44	131.56
Chi Square Value	1.17			
P-value	0.280			

Table 7 Analysis of the relationship between parasite and fungal infection diagnoses

Statistic	*Parasitic and Fungus*	*Parasitic and No Fungus*	*Non-parasitic and Fungus*	*Non-parasitic and No Fungus*
Observed Occurrence	5	62	12	182
Theoretical Occurrence	4.36	62.64	12.64	181.36
Chi Square Value	0.13			
P-value	0.715			

Table 8 Analysis of the relationship between parasite and allergy diagnoses

Statistic	*Parasitic and Allergies*	*Parasitic and No Allergies*	*Non-parasitic and Allergies*	*Non-parasitic and No Allergies*
Observed Occurrence	9	58	16	178
Theoretical Occurrence	6.42	60.58	18.58	175.42
Chi Square Value	1.55			
P-value	0.214			

Table 9 Analysis of the relationship between parasite diagnoses and gender

Statistic	*Parasitic and Female*	*Parasitic and Male*	*Non-parasitic and Female*	*Non-parasitic and Male*
Observed Occurrence	39	23	123	56
Theoretical Occurrence	24.07	29.11	75.93	70.89
Chi Square Value	0.71			
P-value	0.401			

Logistic Regression

We analyzed the relationship between the number of diagnoses per occupant and the number of occupants per household (H_0: $\beta=0$, H_1: $\beta\neq0$) (Table 10 and Figure 11). No significant relationship was determined, $p=0.699$ ($N=42$).

We analyzed the relationship between parasite diagnosis and age (Table 11). Age was the independent variable; parasite diagnosis was the response. The relationship is not likely significant, although the results suggest that younger people are more likely to have parasites, $p=0.246$ ($N=241$).

We analyzed the relationship between occupants per household and average blood pressure (H_0: $\beta=0$, H_1: $\beta\neq0$) (Table 13 and Figure 12). The analysis used the average of the systolic and diastolic blood pressure. Pearson's Correlation Coefficient indicates that there may be a significant inverse relationship between occupants per household and blood pressure, $p=0.06$ ($N=17$).

Table 10 Regression and ANOVA statistics of diagnoses per occupant versus occupants per household

Regression Statistics	
Multiple R	0.061
R Square	0.004
Adjusted R Square	-0.021
Standard Error	0.829
Observations	42

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.10	0.10	0.15	0.70
Residual	40	27.51	0.69		
Total	41	27.62			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.207	0.315	3.834	0.000	0.571	1.844	0.571	1.844
Occupants per Household	-0.018	0.046	-0.389	0.699	-0.112	0.076	-0.112	0.076

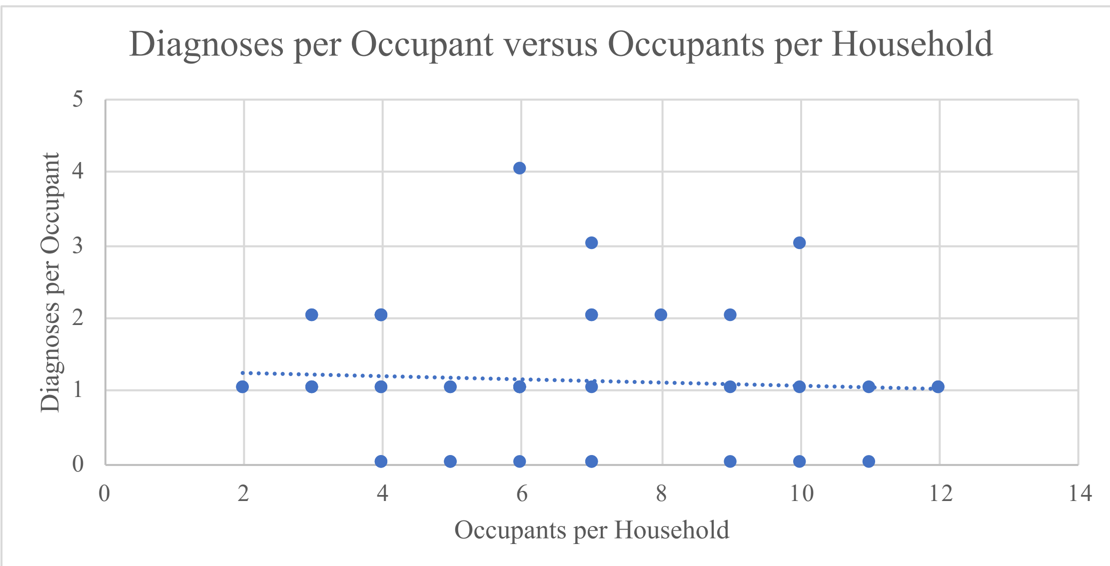

Figure 11: Number of diagnoses per occupant versus occupants per household

Table 11 Logistic regression analysis and odds ratio estimate of the relationship between parasites and age

Parameter	*DF*	*Estimate*	*Standard Error*	*Wald Chi-Square*	*Pr > Chi Square*
Intercept	1	0.86	0.23	14.21	0.000
Age (Years)	1	0.01	0.01	1.35	0.246

Effect	*Point Estimate*	*95% Wald Confidence Limits*
Age Years	1.008	0.995 to 1.021

Table 12 Simple statistics of patient blood pressures

Variable	*N*	*Mean*	*Std Dev*	*Sum*	*Minimum*	*Maximum*
Systolic BP	74	148.38	28.49	10980	96	233
Diastolic BP	74	90.18	14.84	6673	61	152
Mean BP	74	119.28	19.20	8827	85.5	188
Occupants per Household	43	6.19	2.75	266	2	12

Table 13 Pearson correlation coefficients for average blood pressure versus occupants per household

	Systolic	*Diastolic*	*Mean BP*	*Number at Home*
Systolic BP	1	0.52	0.94	-0.39
		< 0.0001	< 0.0001	0.1193
	74	74	74	17
Diastolic BP	0.52	1	0.77	-0.14
	< 0.0001		< 0.0001	0.58
	74	74	74	17
Mean BP	0.94	0.77	1	-0.46
	< 0.0001	< 0.0001		0.06
	74	74	74	17
Number At Home	-0.39	-0.14	-0.46	1
	0.12	0.58	0.06	
	17	17	17	43

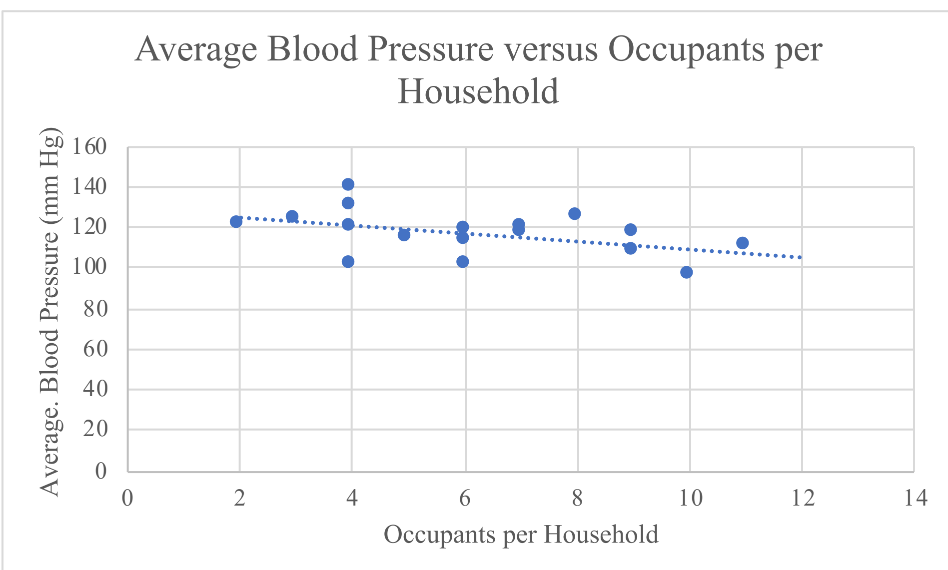

Figure 12: Average blood pressure versus occupants per household

Diagnosis Alleviation

The total number of different types of diagnoses was 68. The total number of diagnoses was 524 (Table 14). The diagnoses were divided into two groups, acute conditions that could be alleviated by medication prescribed on the mission trip (Table 15), and chronic conditions beyond the scope of treatments provided by the medical mission team (Table 16). The number of individual types of diagnoses potentially alleviated during the mission trip was 30. In total, the number of diagnoses potentially alleviated was 360. In comparison, the number of distinct diagnoses *not* alleviated during the mission trip was 36 and the total number of diagnoses not alleviated was 152. The percentage of diagnoses potentially alleviated on the mission trip was 69%. It was unclear how quickly some diagnoses, such as “dermatological”, could be improved. These diagnoses were not included in either group.

Table 14 Diagnoses made by the medical mission team

Diagnosis	Incidence
Allergies	25
Alzheimer's disease	1
Anemia	6
Aphagia	1
Arthralgia	6
Arthritis	31
Athletes foot	3
Bacterial vaginosis	7
Biliary colic	1
Bronchitis	1
Bug bites	4
Bullous impetigo	1
Malar rash	1
Candida albicans	1
Cardiac dysfunction	1
Congenital glaucoma	1
Constipation	1
Corrective lens	111
Croup	11
Cyst	2
Dehydration	20
Dermatological	9
Developmental condition	1
Diabetes	2
DUB	1
Esotropia (cross eyed)	1
Fungal infection	3
Gastritis	1
GER	33
GERD	14
Hearing loss	1
Hemmorhage	1
Hemorrhoids	1
Hepatitis	1
Hernia	2
Hypertension	15

ID	1
Impetigo	1
Indigestion	3
Infection	5
Insomnia	4
Kidney disease	3
Lesion	1
Lice	2
Malnutrition	1
Mastocytosis	1
Osteoarthritis	6
Osteochondritis	1
Otitis media	6
Parasites	67
Pnemonia	2
Renal dysfunction	2
Skeletal dysphoria	1
Somatic dysfunction	1
STI	3
Tachycardia	2
Tendonitis	2
Dental caries	35
Tuberculosis	3
Ulcer	6
Umbilical discharge	1
URI	17
UTI	6
Vaginitis	4
Varicose veins	3
Viral gastritis	1
Vision disorder	1
Yeast infection	10
Sum of diagnoses	524

Notable abbreviations: DUB, dysfunctional uterine bleeding; GER, gastroesophageal reflux; GERD, gastroesophageal reflux disease; ID, intellectual disability; STI, sexually transmitted infection; URI, upper respiratory infection; UTI, urinary tract infection

Table 15 Acute treatable diagnoses and incidence

Acute Treatable Diagnoses	Incidence
Athletes foot	3
Bacterial vaginosis	7
Biliary colic	1
Bronchitis	1
Bug bites	4
Bullous impetigo	1
Malar rash	1
Candida albicans	1
Constipation	1
Corrective lens	111
Croup	11
Dehydration	20
DUB	1
Fungal infection	3
Gastritis	1
GER	33
Impetigo	1
Indigestion	3
Infection	5
Lice	2
Otitis media	6
Parasites	67
STI	3
Dental caries	35
URI	17
UTI	6
Vaginitis	4
Viral gastritis	1
Yeast infection	10
Sum of diagnoses	360

Table 16 Chronic non-treatable diagnoses and incidence

Chronic Non-treatable Diagnoses	Incidence
Allergies	25
Alzheimer's disease	1
Anemia	6
Aphagia	1
Arthralgia	6
Arthritis	31
Biliary colic	1
Cardiac dysfunction	1
Congenital glaucoma	1
Cyst	2
Developmental condition	1
Diabetes	2
Esotropia (cross eyed)	1
GERD	14
Hearing loss	1
Hemmorhage	1
Hemorrhoids	1
Hepatitis	1
Hernia	2
Hypertension	15
ID	1
Insomnia	4
Kidney disease	3
Malnutrition	1
Mastocytosis	1
Osteoarthritis	6
Osteochondritis	1
Renal dysfunction	2
Skeletal dysphoria	1
Somatic dysfunction	1
Tachycardia	2
Tendonitis	2
Tuberculosis	3
Ulcer	6
Varicose veins	3
Vision disorder	1
Sum of diagnoses	152

Table 17 Maximum statistical power analysis

Statistical Significance	*Power*
0.05	21%
0.1	47%
0.15	73%
0.2	90%

Discussion

The purpose of this study was to retrospectively analyze medical records of 262 patients who attended a two-day clinic in La Ceiba Dudu, Nicaragua, in December 2014. We found a slight negative correlation between patient blood pressure and occupants per household (p=0.06) (Table 13), a marginally negative relationship between patient BMI and parasite diagnosis (p=0.07) (Table 4), a slightly negative correlation between parasite diagnosis and GER (p=0.134) (Table 5), and that healthcare providers could treat most ailments (69%) during the medical mission trip (Table 14, 15, and 16).

Two Sample Independent T-Test Data Analysis

Analysis of the Relationship between Parasites and Age

Our analyses suggest that young populations have a higher prevalence of parasitic infections than older populations (Table 2 and Table 11). This finding agrees with a substantial body of literature (Colditz et al. 1996; Gebretsadik et al. 2018; Rivero et al. 2017; World Health Organization 2020). The increased prevalence in younger populations is likely due to behaviors common to children like close contact play, frequent recreational water activities, and disregard for avoiding contaminated drinking sources and infected peers (CDC 2020). Further, Sol et al. (2003) suggest that juvenile hosts are innately more susceptible to parasitic infections because they are still developing an acquired immunity. Similarly, research by Lynsdale et al. (2017) showed that the percentage of deaths attributed to parasites is dramatically higher in younger elephant populations than older populations. The same relationship is presumably true in human populations, emphasizing the severity of parasitic infections in the youth.

Analysis of the Relationship between Parasites and Height

Our results indicate that people diagnosed with parasites were shorter (56 in) compared to their non-parasitic counterparts (57 in) (Table 3). However, the results are not statistically significant (p=0.18). Prior research by Oliveria et al. (2015) and Shang et al. (2010) indicated that parasitic infections could lead to stunting in school-aged children. This relationship likely stems from malnutrition caused by parasitic infections (Sackey et al. 2003; Beltrame et al. 2002). Conversely, research by Ihejirka et al. (2019) found no significant correlation between parasitic infection and stunting in children. Our results indicate that people with parasites tended to be shorter than people without parasites; however, this does not demonstrate a cause and effect relationship, nor is the correlation statistically significant. We analyzed patients of all ages, which allowed age to act as a confounding variable as the non-parasitic population's mean age was over four years greater than the parasitic population's mean age. Although it appears that patients diagnosed with parasites tend to be shorter, we recommend further research to determine the relationship between parasite diagnosis and patient height.

Analysis of the Relationship between Parasites and BMI

We found that the parasitic population's BMI was considerably lower than the BMI of the non-parasitic population (p=0.07) (Table 4). We anticipated this difference as multiple studies demonstrated parasitic infections' negative relationship with body weight (Shea-Donohue et al. 2017; Yang et al. 2013). This correlation presumably occurs because of parasites' abilities to alter the intestinal barrier function, regulate glucose transport, reduce appetite (Shea-Donohue et al. 2017), and downregulate key enzymes required for lipogenesis (Yang et al. 2013). However, research by Macada-Veiga et al. (2016) and Marcogliese and Pietrock (2011) indicate that the effect of parasites on metabolism can vary considerably depending on body condition, parasite load, parasite species, and life cycle of the parasite. While the mean BMI was less, age may act as a confounding variable because children have lower BMIs than adults (CDC 2020), and the parasitic population was younger than the non-parasitic population. Further, BMI is a ratio between height and weight. Thus, if the parasite infection reduced both height and weight approximately equally, BMI could remain relatively unaffected. Despite these limitations, the results indicate that people with lower BMIs are more often diagnosed with parasites.

Chi-Square Data Analysis

Analysis of the Relationship between Parasite and Gastroesophageal Reflux (GER)

Although our results did not reach significance, we noted an interesting trend of a possible connection between parasite and gastroesophageal (GER). A recent study found an increased risk for chronic gastrointestinal disorders following an acute intestinal parasite infection which included GERD (Blitz et al. 2018). A possible trend might have emerged due to intestinal parasites causing damage which leads to vulnerability to GI disorders. Interruptions to the normal functioning of the intestines can initiate a causal sequence of medical issues within the GI tract.

Another study done specifically with *Giardia lamblia* recognized increased risk of development of IBS post parasitic infection (Dormond et al. 2016). This study demonstrated a possible connection between parasitic infection in the intestines and the development of other problems in the GI tract. GER is an acute condition that can develop into chronic GERD (gastroesophageal reflux disease). Contrary to the sources about GER and parasitic infection, our study indicated a trend of people with parasites have less GER. More research is currently being done to search for causative relationships between parasitic infections and chronic gastrointestinal disorders.

Analysis of the Relationship between Parasite and Infection Diagnoses

We found no significant correlation between parasite infections and other diagnoses. The category for infections covers a wide and diverse number of conditions. Our team had a limited number of diagnostic tests. Perhaps more conditions would have been diagnosed if we had tests for stool samples, specific blood tests, or throat swabs. Parasites may weaken the immune system, leaving the body vulnerable to other infections (Vaumourin et al. 2015). This understanding would lead to a higher amount of diagnoses than what is shown in Table 6. Our results trend in the right direction, but they are underpowered and do not show significance.

Analysis of the Relationship between Parasite and Fungal Infection Diagnoses

Fungal infections are difficult to diagnose without the necessary lab tools and instruments. Our clinic made a visual diagnosis based on gross appearance without a microscope, which could lead to underdiagnosis. However, our numbers do not trend in the direction of a relationship. There is a scarce amount of research that analyzes this potential diagnosis relationship. The fungal infections diagnosed in the clinic were on superficial surfaces of the body. Therefore, it is more difficult to find a connection between intestinal parasite infection and topical fungal infections. However, fungal infections can occur in the intestines especially in patients who are immunocompromised (Lamps 2014). It might be more efficient for researchers to search for a connection between parasitic and fungal infections in the intestines.

Analysis of the Relationship between Parasite and Allergy Diagnoses

We expected a lower number of patients with both parasites and allergies, with the theoretical occurence being 6.42 and the actual occurrence being 9. However, our results were above significance and inconclusive. A 2009 study that searched for a relationship between parasites and allergies found no direct correlation (Cooper 2009). The study mentioned that helminths could affect the anti-inflammatory response made by the body, which could indirectly affect the change in the allergic response of the body. A 1987 study postulated that helminths adapt to more specific immune responses by producing allergens that cause a release of polyclonal IgE (Lynch et al. 1987). The production of IgE's are relevant since they are involved with the immune response to allergens. Allergies may also be considered less of a severe problem therefore doctors might not mention them to prioritize other issues if there is a limited time and interaction with the doctor. Also, lack of medication that can alleviate the symptoms of allergies, like antihistamines, might prevent doctors from making an official diagnosis.

Analysis of the Relationship between Parasite and Gender

The relationship between parasite diagnoses and gender was not significant. We predicted there would be a lower prevalence of parasites in women than in men, with an expected occurrence of around 24 and an observed occurrence of 39. However, our results trended in the opposite direction. A recent report found gender as a predictor for intestinal parasitic infections (Feleke et al. 2019). A study in a Nigerian hospital, however, found no direct correlation between intestinal infections and gender (Akinbo et al. 2011). For our population, water contamination and gender-specific work done by females and males within the community could affect their exposure to parasites. For example, if a majority of men work on farms compared to women and are supplied water at their jobs, this would be a different source of water exposure than women.

Linear Regression Data Analysis

Blood pressure and Occupants per Household

The correlation found between the patients' blood pressures and the number of people living in that household was close to the set level of significance ($p<05$) despite our study's lack of power. The relative trend that was found may, however, be due to a confounding variable of age. Households with a larger quantity of occupants are prone to having more children in the house than adults, both male and female. Children typically have significantly lower blood pressures than adults (Uhari et al., 1991). We suspect that the suggestion of correlation, then, may actually be incorrect.

On the other hand, there is evidence to support the idea that larger households are associated with lower blood pressure. A self-rated health score study was performed by Hughes and Waite to measure the relationship between health and living arrangements. The study concluded that families with married parents and more than one child had significantly higher self-rated health scores. Hughes and Waite attributed this to the healthy social dynamic leading to better mental health. This evidence could conclude a decreased stress level, thus reducing blood pressure (Hughes & Waite 2006). Our data support this theory as the blood pressure decreased as the occupants per household increased (**Figure 12**).

Occupants per Household and Diagnoses per Patient

Figure 11 shows the lack of relationship from our data. WHO Housing and Health Guidelines found a relationship between household crowding and the tendency to contract infectious diseases (World Health Organization 2018). Evidence from multiple studies collected by WHO is abundant for a direct correlation between incidence of infectious disease and number of people in the household. We hope to collect additional data about our population in this regard in the future.

Diagnosis Alleviation Data Analysis

Out of the 524 diagnoses, we estimate that our medical staff was able to provide helpful aid to 360 (69%) of these (Table 14) on the mission trip. However, like most medical mission trips, follow up patient data was not provided for any patients. This lack of ongoing medical care falls well below the standards for medical care that are normative in most developed countries (Sykes 2014). Treating over two-thirds of all ailments presented is a testament to the beneficial impact that medical mission trips offer and supports prior research by Maki et al. (2008).

The literature on the efficiency of medical mission trip interventions is growing rapidly (Chen et al. 2012). While the cost of medical mission trip interventions is beyond the scope of this study, it is noteworthy that providing corrective lenses to 111 patients and parasite medication to 67 patients alleviated far more ailments than any other interventions. As alluded to by Patel et al. (2006), providing glasses dramatically and immediately alters patients' quality of life and daily abilities by enabling sewing, food preparation, and reading. Likewise, providing a single dose of metronidazole or mebendazole immediately treats parasitic infections. Some drugs such as Ivermectin even provide up to twelve months of protection from reinfection (Ivermectin 2020). The fast-acting mechanism and longevity of protection provided by a single dosage of antiparasitic medication makes these drugs ideal medical mission trip treatments.

Despite these outcomes, some experts criticize short term medical trips. Lupton (2011) argues that these trips are not a wise way to invest in impoverished communities as they do not benefit the recipients beyond the initial service. He suggests that some missionaries are more concerned with satisfying altruistic desires than making a beneficial lasting impact (Lupton 2011). Our research provides an explanation for this stigma. Lupton’s belief may result from the breadth of chronic diseases overshadowing the lasting positive outcomes of medical mission trips. Tables 15 and 16 indicate that while healthcare providers could entirely treat 69% of the ailments during the short-term medical mission trip, 36 different types of diagnoses could not be alleviated compared to only 30 different types of diagnoses that could be alleviated. This enigma is likely a result of sophisticated medications and interventions developed to treat the most common ailments while the number of uncommon and currently untreatable chronic ailments continues to grow (Drexler M 2010).

Limited knowledge of the medical mission trip outcomes and variability between medical mission trips restrict these conclusions. We must infer patient outcome based solely on the diagnosis. Patient outcomes vary significantly between patients based on many factors, including disease progression, patient overall health and demographics, and comorbidities (Braveman and Gottlieb 2014). The wide variability between medical mission trip resources, personnel, and communities served limits the generalization of these results (Syke 2014). However, our research agrees with the literature provided by Syke (2014) in that short-term medical mission trips can provide benefits to impoverished communities and arguably can leave a lasting positive impact.

Limitations

Limitations include but are not restricted to low statistical power, illegible and confusing documentation of patient records, inexperienced medical student diagnoses, and lack of a control population. We obtained data from handwritten patient report sheets. We omitted data that could not be interpreted. To limit these sources of error, we collaborated to interpret physicians' handwriting.

Additionally, many patient records included diagnoses in the chief complaint section. This inaccuracy raised the question of whether or not the patient was correctly diagnosed with the complaint. Conversely, some patient sheets included symptoms listed in the diagnosis section. Authors used their best judgment to include accurate results in analyses.

Two four-year medical students diagnosed patients under the supervision of an experienced physician, which might have increased inappropriate diagnoses. Further, the medical team lacked the instruments necessary for proper diagnoses of various conditions. Therefore, many patients received analgesics for pain without a definitive diagnosis of the underlying pathology.

We were not able to locate a community similar to the La Ceiba Dudu Nicaraguan population. Thus, all analyses were made within the La Ceiba Dudu population. For all comparisons between parasitic and non-parasitic groups, community exposure to parasites may act as a moderating variable limiting the differences between the two populations. The entire population may be affected by parasites and thus the significance of correlations between people with parasite diagnoses and people without parasite diagnoses may be reduced.

The data we analyzed is not an accurate representation of the entire community. This sample group had symptoms that the people were willing to go see a foreign doctor. The population that visited the clinic probably saw it as an opportunity to possibly mend or heal their medical issues that were significant enough to call to attention. The data represents a small subgroup of Nicaraguans that does not provide an overall image of the health problems within the entire town of La Ceiba.

The power analysis (Table 17) shows that the study may not have enough data (patients) to detect significance at the $\alpha=0.05$ level. When setting significance at the standard $\alpha=0.05$ and analyzing all 262 patients, the analysis power is 21%. Thus, we expect that 79% of the time, we will not pick up real relationships between variables. It is not until $\alpha=0.20$ that the power of the study is a reasonable 90%.

In light of this power analysis, all results with a p-value less than 0.20 deserve recognition for potential significance as they could be skewed by the low statistical power. This includes the correlation between parasite diagnoses and height ($p=0.18$), the relationship between parasite diagnosis and GER (p=0.134), the inverse correlation between blood pressure and occupants per household (p=0.06) and the negative relationship between parasite diagnoses and patient BMI (p=0.07). Further, only analyses of the relationship between parasites and GER, infections, fungal infections, and allergies used all 262 patients; therefore, all other analyses will all have even lower statistical power.

In conclusion, we analyzed 262 patient records from a two-day clinic in La Ceiba Dudu, Nicaragua. We suspect real correlations between parasite diagnosis and patient BMI as well as occupants per household and average blood pressure. Other potential relationships that warrant further research include the effect of parasite diagnoses on stunting and the relationship between parasite diagnoses and GER diagnoses. We found that short term medical mission trips may offer lasting community health benefits and do not deserve scrutiny. We recommend analyzing a larger population to determine the effect of medical mission trips on community health.

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Literature Cited

Adam RD. 2001. Biology of *Giardia lamblia*. American Society for Microbiology 14(3): 447-475.

Agren D. 2018. Criminalization of health care in Nicaragua's political crisis. The Lancet. 392(10150):807-808.

Akinbo F, Omoregie R, Eromwon R, Igebenimah I, Airueghiomon U. 2011. Prevalence of intestinal parasites among patients of a tertiary hospital in Benin city, Nigeria. North American journal of medical sciences. 3(10):462-464.

Alicea-Planas J, Greiner L, Greiner PA. 2016. Hypertension and Related Lifestyle Factors Among Persons Living in Rural Nicaragua. Applied Nursing Research. 29:43-46.

Beltrame A, Scolari C, Torti C, Urbani C. 2002. Soil transmitted helminth (STH) infections in an indigenous community in Ortigueira, Paraná, Brazil and relationship with its nutritional status. Parassitologia. 44(3–4):137–139.

Blitz J, Riddle M, Porter C. 2018. The Risk of Chronic Gastrointestinal Disorders Following Acute Infection with Intestinal Parasites. Frontiers in Microbiology. 9(17).

Bonavire K, Williams G, Sastre L. 2019. P128 Diet Quality, Food Access, Obesity and Hypertension Risk in Rural Nicaragua. Journal of Nutrition Education and Behavior. 51(7).

Braveman P, Gottlieb L. 2014.The social determinants of health: it's time to consider the causes of the causes. Public health reports (Washington, D.C.: 1974). 129 Suppl (1_suppl2):19–31.

Britannica.com. <https://www.britannica.com/topic/Sandinista> Accessed 2020 Nov 14.

Carrie H, Mackey TK, Laird SN. 2015. Integrating Traditional Indigenous Medicine and Western Biomedicine and Health Systems: A Review of Nicaraguan Health Policies and Miskitu Health Services. International Journal for Equity in Health. 14:129.

Caspia M, Joseph SA, Nunez C, Rahme E, Gyorkos TW. 2006. Parasite risk factors for stunting in grade 5 students in a community of extreme poverty in Peru. International Journal for Parasitology. 36: 741-747.

Central America :: Nicaragua — the world factbook - central intelligence agency. <https://www.cia.gov/library/publications/the-world-factbook/geos/nu.html> Accessed 2020 Nov 14.

Chen AT, Pedtke A, Kobs JK, Edwards GS Jr, Coughlin RR, Gosselin RA. 2012 Volunteer Orthopedic surgical trips in Nicaragua: a cost-effectiveness evaluation. World journal of surgery. 36(12):2802–2808.

Children. Cdc.gov. 2020 Oct 21 <https://www.cdc.gov/parasites/children.html> Accessed 2020 Nov 7.

Colditz IG, Watson DL, Gray GD, Eady SJ. 1996. Some relationships between age, immune responsiveness and resistance to parasites in ruminants. International journal for parasitology. 26(8–9):869–877.

Cooper PJ. 2009. Interactions between helminth parasites and allergy. Current opinion in allergy and clinical immunology. 9(1):29-37.

Dormond M, Gutierrez R, Porter C. 2016. Giardia lamblia infection increases risk of chronic gastrointestinal disorder. Tropical diseases, travel medicine and vaccine. 2(17).

Drexler M, Institute of Medicine (US). Prevention and treatment. Washington, D.C., DC:

National Academies Press; 2010.

Feldmeier H, Jackson A, Ariza L, Calheiro CML, Soares VL, Oliviera FA, Hengge UR, Heukelbach J. 2009. The Epidemiology of Scabies in an Impoverished Community in Rural Brazil: Presence and Severity of Disease are Associated with Poor Living Conditions and Illiteracy. Journal of the American Academy of Dermatology. 60(3): 36-443.

Feleke BE, Beyene MB, Feleke TE, Jember TH, Abera B. 2019. Intestinal parasitic infection among household contacts of primary cases, a comparative cross-sectional study. PLoS ONE. 14(10)

Fernald LC, Gutierrez JP, Neufeld LM, Olaiz G, Bertozzi SM, Mietus-Snyder M, Gertler PJ. 2004. High prevalence of obesity among the poor in Mexico. JAMA: the journal of the American Medical Association. 291(21):2544–2545.

Finegold SM. 1980. Metronidazole. Annals of Internal Medicine 93(4): 585-587.

Freeman CD, Klutman NE, Lamp KC. 2012. Metronidazole. Drugs 54: 679-708.

Gardner TB. Hill DR. 2001. Treatment of Giardiasis. American Society for Microbiology 14(1): 114-128.

Gebretsadik D, Metaferia Y, Seid A, Fenta GM, Gedefie A. 2018. Prevalence of intestinal parasitic infection among children under 5 years of age at Dessie Referral Hospital: cross sectional study. BMC research notes. 11(1):771.

Giardia. Cdc.gov. 2019 Jun 24 <https://www.cdc.gov/parasites/giardia/index.html> Accessed 2020 Nov 14.

Haynes R, Gale S. 2000. Deprivation and Poor Health in Rural Areas: Inequalities Hidden by Averages. Health & Place. 6(4): 275-285.

Hemphill A, Mueller J, Esposito M. 2006. Nitazoxanide, a broad-spectrum thiazolide anti-infective agent for the treatment of gastrointestinal infections. Expert Opinion on Pharmacotherapy 7(7): 953-964.

Heukelbach J, Haeff EV, Rump B, Wilcke T, Moura RCS, Feldmeier H. 2003. Parasitic skin diseases: health care-seeking in a slum in north-east Brazil. Tropical Medicine and International Health. 8(4): 368-373.

Holden BA, Sulaiman S, Knox K. The Challenge of Providing Spectacles in the Developing World.

Household crowding. Genève, Switzerland: World Health Organization; 2018.

Hughes ME, Waite LJ. 2006. Health in Household Context: Living Arrangements and Health in Late Middle Age. Journal of Health and Social Behavior 43(1): 1-21

Ihejirika OC, Nwaorgu OC, Ebirim CI, Nwokeji CM. 2019. Effects of intestinal parasitic infections on nutritional status of primary children in Imo State Nigeria. The Pan African medical journal. 33:34.

Institute of Medicine. What you need to know about infectious disease. Washington, D.C.: National Academies Press; 2011.

Importance of affordable eye care. Community eye health. 2001;14(37):1–3.

Karan A, Chapman GB, Galvani A. 2012. The Influence of Poverty and Culture on the Transmission of Parasitic Infections in Rural Nicaraguan Villages. Journal of Parasitology Research. 2012:1-12

Kyndt M. Importance of Affordable Eye Care. 2001. Community Eye Health. 14(37).

Lamps LW, Lai KKT, Milner DA Jr. Fungal infections of the gastrointestinal tract in the immunocompromised host: an update: An update. Advances in anatomic pathology. 2014;21(4):217–227.

Laux TS, Bert PJ, Gonzalez M, Unruh M, Aragon A, Lacourt CT. 2012. Prevalence of obesity, tobacco use, and alcohol consumption by socioeconomic status among six communities in Nicaragua. Revista Panamericana De Salud Pública. 32(3): 217-225.

Loftus B, Anderson I, Davies R, Alsmark UCM, Samuelson J, Amedeo P, Roncaglia P, BerrimenM, Hirt RP, Mann BJ, Nozaki T, Suh B, Pop M, Duchene M, Ackers J, Tannich E, Leippe M, Hofer M, Bruchhaus I, Willhoeft U, Bhattacharya A, Chillingworth T, Chircher C, Hance Z, Harris B, Harris D, Jagels K, Moule S, Mungall K, Ormond D, Squares R, Whitehead S, Quail MA, Rabbinowitsch E, Norbertczak H, Price C, Wang Z, Guillen N, Gilchrist C, Stroup SE, Bhattacharya S, Lohia A, Foster PG, Sicheritz-Ponten T, Weber C, Singh U, Mukherjee C, El-Sayed NM, Petri Jr WA, Clark CG, EMbley TM, Barrel B, Fraser CM, Hall N. 2005. The genome of the protist parasite *Entamoeba histolytica* 433:865-868

Lupton RD. 2011. Toxic charity: How the church hurts those they help and how to reverse it. HarperSanFrancisco.

Lynch NR, Perez M, Lopez RI. 1987. Measurement of anti-Ascaris Ige antibody levels in tropical allergic patients, using modified ELISA. Allergol Immuno Pathol. 15:19-24

Lynsdale CL, Mumby HS, Hayward AD, Mar KU, Lummaa V. 2017. Parasite-associated mortality in a long-lived mammal: Variation with host age, sex, and reproduction. Ecology and evolution. 7(24):10904–10915.

Ma X, Zhou Z, Yi H, Pang X, Shi Y, Chen Q, Meltzer ME, le Cessie S, He M, Rozelle S. 2014. Effect of providing free glasses on children's educational outcomes in China: cluster randomized controlled trial. BMJ (Clinical research ed.). 349

Maceda-Veiga A, Green AJ, Poulin R, Lagrue C. 2016. Body condition peaks at intermediate parasite loads in the common bully Gobiomorphus cotidianus. PloS one. 11(12):e0168992.

Maki J, Qualls M, White B, Kleefield S, Crone R. 2008. Health impact assessment and short-term medical missions: a methods study to evaluate quality of care. BMC services research. 8(1):121.

Manna D, Ehrenkaufer GM, Lozano-Amado D, Singh U. 2020. *Entamoeba* stage conversion: progress and new insights. Current Opinion in Microbiology 58: 62-68

Marcogliese DJ, Pietrock M. 2011. Combined effects of parasites and contaminants on animal health: parasites do matter. Trends in parasitology. 27(3):123–130.

Mosadeghrad AM. 2014. Factors affecting medical service quality. Iranian journal of public health. 43(2):210–220.

Murthy KR, Murthy PR, Kapur A, Owens DR. 2012. Mobile Diabetes Eye Care: Experience in developing countries. Diabetes Research and Clinical Practice. 97: 343-349.

Nicaragua 2001: results from the Demographic and Health Survey. Studies in family planning. 2004;35(3):207–211.

Oberhelman RA, Guerrero ES, Fernandez ML, Silio M, Mercado D, Comiskey N, Ihenacho G, Mera R. 1998. Correlations between Intestinal Parasitosis, Physical Growth, and Psychomotor Development among Infants and Children from Rural Nicaragua. The

American Journal of Tropical Medicine and Hygiene. 58(4): 470-475.

Oliveira D, Ferreira FS, Atouguia J, Fortes F, Guerra A, Centeno-Lima S. 2015. Infection by intestinal parasites, stunting and anemia in school-aged children from southern Angola. PloS one. 10(9)

Olusanya B, Onoja G, Ibraheem W, Bekibele C. 2012. Profile of Patients Presenting at a Low Vision Clinic in a Developing Country. BMC Ophthalmology. 12(1).

Oxlade O, Murray M. Tuberculosis and Poverty: Why Are the Poor at Greater Risk in India?

Pena R, Perez W, Melendez M, Kallestal C, Persson L. 2008. The Nicaraguan Health and Demographic Surveillance Site, HDSS-Le`on: A Platform for Public Health Research. Scandinavian Journal of Public Health. 36: 318-325.

Perez W, Contreras M, Pena R, Zelaya E, Persson L, Kallestal C. 2018. Food insecurity and self-rated health in rural Nicaraguan women of reproductive age: a cross-sectional study. International Journal for Equity in Health. 17(1)

Pinzari L, Mazumdar S, Girosi F. 2018. A Framework for the Identification and Classification of Homogeneous Socioeconomic Areas in the Analysis of Health Care Variation. International Journal of Health Geographics. 17(1).

Prado AM, Calderon D, Zuniga R. 2016. Providing Low-Cost and High-Quality Medications to Rural Communities in Developing Countries: The Case of Accion Medica Cristiana in Nicaragua. Journal of Business Research. 69: 3910-3922.

Quesada J. 2008. Suffering Child: An Embodiment of War and Its Aftermath in Post-Sandinistas Nicaragua. Medical Anthropology Quarterly 12(1).

Rivero MR, De Angelo C, Nuñez P, Salas M, Motta CE, Chiaretta A, Salomón OD, Liang S. 2017. Environmental and socio-demographic individual, family and neighborhood factors associated with children intestinal parasitoses at Iguazú, in the subtropical northern border of Argentina. PLoS neglected tropical diseases. 11(11)

Rosado-Garcia FM, Guerrero-Florez M, Karanis G, Hinojosa MDC, Karanis P. 2017. Water-Borne Protozoa Parasites: The Latin American Perspective. International Journal of Hygiene and Environmental Health. 22: 783-789.

Sackey M-E, Weigel MM, Armijos RX. 2003. Predictors and nutritional consequences of intestinal parasitic infections in rural Ecuadorian children. Journal of tropical pediatrics. 49(1):17–23.

Sandiford P, Gorter AC, Smith GD, Pauw JPC. 1989. Determinants of drinking water quality in rural Nicaragua. Epidemiology and Infection. 102(3): 429-438.

Schwab L. Eye care delivery in developing nations: paradigms, paradoxes, and progress. Ophthalmic epidemiology. 1994;1(3):149–154.

Shea-Donohue T, Qin B, Smith A. 2017. Parasites, nutrition, immune responses and biology of metabolic tissues. Parasite immunology. 39(5):e12422.

Shang Y, Tang L-H, Zhou S-S, Chen Y-D, Yang Y-C, Lin S-X. 2010. Stunting and soil-transmitted-helminth infections among school-age pupils in rural areas of southern China. Parasites & vectors. 3(1):97.

Soil-transmitted helminth infections. WHO International <https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-

Infections> Accessed 2020 Nov 7.

Sol D, Jovani R, Torres J. 2003. Parasite mediated mortality and host immune response explain age-related differences in blood parasitism in birds. Oecologia. 135(4):542–547.

Staessen J, Wang J, Bianchi G, Birkenhager WH. 2003. Essential hypertension. The Lancet 361(9369):1692-1641.

Stanley Jr SL. 2003. Amoebiasis. The Lancet 361(9362): 1025-1034.

Sykes KJ. 2014. Short-term medical service trips: a systematic review of the evidence. American journal of public health. 104(7):38-48.

Tellez A, Morales W, Rivera T, Meyer E, Leiva B, Linder E. 1997. Prevalence of Intestinal Parasites in the Human Population of Leon, Nicaragua. Acta Tropica. 66:119-125.

Tercero F, Andersson R, Pena R, Rocha J, Castro N. 2006. The Epidemiology of Moderate and Severe Injuries in a Nicaraguan Community: A Household-Based Survey. Public Health. 120(2):106-114.

Uhari M, Nuutinen EM, Turtinen J, Pokka T, Kuusela V, Akerblom HK, Dahl M, Kaprio EA, Pesonen E, Pietikainen M, Salo MK, Viikari J. 1991. Blood Pressure in Children, Adolescents and Young Adults. Annals of Medicine 23(1):47-51.

Valladares MJ, Sandigo NAR, Rivera GOR, Jarquin MAR, Castillo RMR, Bonilla IML. 2019. Prevalence, Awareness, Treatment, and Control of Hypertension in a Small Northern Town in Nicaragua: The Elieth-HIFARI Study. Health Science Reports. 2(7).

Vaumourin E, Vourch G, Gasqui P, Vayssir-Taussat M. 2015. The importance of multiparasitism: examining the consequences of co-infections for human and animal health. 8:545

Vique-Sánchez JL, Jiménez-Pineda A, Benítez-Cardoza CG. 2020. Amoebicidal effect of 5,5’-[(4-nitrophenyl)methylene]bis-6-hydroxy-2-mercapto-3-methyl-4(3H)-pyrimidinone), a new drug against Entamoeba histolytica. Archiv der Pharmazie. Giardia. 2015. Centers for Disease Control and Prevention.

United Nations Population Division <http://www.un.org/esa/population/unpop.htm> Accessed 2020 Nov 7.

Yang Z, Grinchuk V, Smith A, Qin B, Bohl JA, Sun R, Notari L, Zhang Z, Sesaki H, Urban JF Jr. 2013. Parasitic nematode-induced modulation of body weight and associated metabolic dysfunction in mouse models of obesity. Infection and immunity. 81(6):1905–1914.

Zaremba LM. 1992. Nicaragua: Before and After the Revolution. Honors Thesis.