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Adverse Health Effects of Intestinal Parasitic Infections in Rural Peruvian Clinic Patients

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Abstract

Intestinal Parasitic Infections (IPIs) pose a significant global health concern. IPIs annually contribute to 3.5 billion infections and 450 million illnesses worldwide. In hyperendemic countries, IPIs pose a significant economic and health burden, especially in rural areas. IPIs have many routes of transmission and cause a wide range of symptoms associated largely with poor health, impeded growth, and worsening of secondary infections. Such diseases are widespread in poor communities living in the Peruvian Amazon. This study aims to describe common chief complaints, diagnoses, treatments, as well as behaviors and practices associated with IPIs presenting in clinic patients. As part of a volunteer health initiative, free medical clinics were held in four communities in the Loreto region of Peru, where 30 patients in each clinic were surveyed for this report. In these four communities, data was compared between moderately poor (MP) and very poor (VP) villages. Data analysis included descriptive statistics and comparisons between the MP and VP groupings. Risk preventability related to IPIs was also explored based on gender, education, literacy, and transmission variables. It was determined that 65% of clinic patients had an IPI (MP: 54%, VP: 76%). Practices and behaviors linked to water, food, sanitation, and zoonotic sources were significantly varied between MP and VP communities. Of the study participants, 67% of MP and 73% of VP were prescribed antiparasitic medication. Socioeconomic status and education were prime indicators of disease susceptibility. In hyperendemic countries like Peru, IPIs need to be further investigated for focused public health intervention strategies.

Keywords: intestinal parasitic infections; low income countries; Peru; public health

Abbreviations:

IPIs: intestinal parasitic infections;

MP: moderately poor;

VP: very poor;

NGOs: non-governmental organizations;

WHO: World Health Organization;

DALY: disability adjusted life years;

PAHO: Pan American Health Organization;

HDI: Human Development Index;

BOD: burden of disease;

CHIMPS: Children's Health International Medical Project of Seattle;

HIS: Health Information System;

MoH: Ministry of Health;

FFAA: Armed Forces;

PNP: National Police;

SIS: Seguro Integrad de Salud;

HIS: Health Information Systems;

AIS-LAC: Action International's Coordinating Office for Latin America and the Caribbean;

EBP: Evidence-Based Practice;

SODIS: Solar Water Disinfection;

MAP: Medical Assistance Program;

SPSS: Statistical Package for the Social Sciences;

IRB: Institutional Review Board;

UHC: Universal Health Coverage;

Adverse Health Effects of Intestinal Parasitic Infections

in Rural Peruvian Clinic Patients

Intestinal Parasitic Infections (IPI) are an important global health concern that have plagued humans since pre-historic times (Gonçalves, Araújo, & Ferreira, 2003). Parasites are organisms that live part or all their lives in a host organism where they derive necessary nutrients, grow, and reproduce. Intestinal parasites are a heterogeneous group of helminths and protozoa that are responsible for billions of infections worldwide. The World Health Organization (WHO) has estimated that 3.5 billion people are affected by IPIs, and 450 million are ill as a result of infestation (Ayalew, Debebe, & Worku, 2011), approximately 50% of which are severely affected children (Moraes Neto et al., 2010). IPIs pose a significant global health challenge in terms of prevention, treatment, and direct patient care (Koplan et al., 2009). Intestinal parasites differ in size from the barely visible microsporidia to feet long like the tapeworm *Taenia saginata*, and either stay in the intestines or travel outside to invade other organs (Mackay & Chiodini, 2003). Evidence supports that IPIs are endemic to the poorest communities in developing countries with weak health infrastructure, and are linked to poor hygiene, sanitation, and a lack of safe water supply (Espinoza et al., 2008; Solomon et al., 2012; Moraes-Neto et al., 2010).

Peru is an upper-middle-income country in South America with a health infrastructure that is not well established (World Bank, 2013). The interrelationship between IPI prevalence, health infrastructure, non-governmental organizations (NGOs), as well as transmissive routes and interventions have, in recent years, become important subjects in global health. The intention of this study is to investigate the health effects of IPIs in rural Peruvian clinic patients. In describing common chief complaints, diagnoses, treatments, and knowledge of risk factors associated with IPIs presenting in clinic patients, the relative impact of IPIs in the region are highlighted and possible intervention strategies can be proposed.

Literature Review

IPIs have always been a global health concern because their prevalence is linked with many key disease transmissive routes. Peru has minimal health infrastructure, especially in rural regions, leading to higher prevalence of diseases that are generally preventable. Medical humanitarian volunteerism exists to fill the void where the government cannot provide medical care. Even so, volunteers do not have the capacity to meet the need, and can potentially hurt the current system if not acting sustainably.

IPIs are commonly manifested as diarrhea and abdominal discomfort. More advanced infestations can present as nausea, vomiting, fever, and weight loss. Some infestations can occur asymptomatically as well. Diarrhea coupled with vomiting and weight loss can lead to malnutrition and wasting which are a significant concern, especially in cases that persist longer than two weeks (Reingold & Gordon, 2012). Approximately three million deaths in children under age five are attributed to diarrhea and pneumonia each year (Kendall-Tachett, 2012). About 90% of IPI related deaths are attributed to poor hygiene, inadequate sanitation, and unsafe water (Hartl & Osseiran, 2006; Morares Neto et al., 2010; Reingold & Gordon, 2012). About 50% of those suffering IPIs are severely affected children and 39 million people lose productive years according to disability adjusted life years (DALY) (Moraes Neto et al., 2010). Peru has a large environmental disease burden with 150-200 deaths per 100,000 in population as of 2002. In Peru, diarrheal diseases caused by IPIs have the largest environmental contribution (Hartl & Osseiran, 2006; Moraes Neto et al., 2010). The major routes of transmission are water, soil, and food, with feces as a major transmissive vehicle.

Socioeconomic and Geopolitical Context

Countrywide context.

Peru is a medium sized country that is one of thirteen countries in South America. Peru's population is 29,075,512 (Gapminder World, 2008), making it the fourth largest South American country. The country has substantial cultural, ethnic, and racial diversity. As depicted in Figure 1, Peru is bordered to the north by Ecuador, northeast by Colombia, east by Brazil, southeast by Bolivia, south by Chile, and west by the Pacific Ocean. These South American countries share a common history, culture, as well as common public health problems (Pan American Health Organization, 2012). Peru's health expenditure is only 5% of its Gross Domestic Product (GDP) – 10 billion dollars out of their 197.1 billion dollar total budget (Gapminder World, 2008; World Bank, 2013). The per capita health expenditure as of 2008 was just $289 for Peru. Nationwide, it is estimated that around half of Peruvian families live in poverty (less than $1.25 U.S. dollars a day), more than 60% of which have at least one unmet basic need (World Health Organization, 2001; World Bank, 2008; PAHO, 2012). The HDI is a composite measure of education, health, and income, and according to Pan American Health Organization's (PAHO) 2012 report, Peru has a Human Development Index (HDI) score of 0.723 which is low in comparison to the United States' score of 0.937 (United Nations Development Program, 2013; PAHO, 2012). Even though the reported national literacy rate is 90%, illiteracy is high in rural areas.

Figure 1. South American countries (PAHO, 2012).

Context within Loreto region.

Peru is divided into 24 regions or states. Loreto is Peru‘s largest region comprising of 142,414.53 square miles; approximately one-third of the country’s territory (PAHO, 2012). Loreto is located in the northeast of the country surrounded by Ecuador to the west, Colombia to the north, and Brazil to the east (4° 0′ 0″ S, 74° 19′ 12″ W). The Loreto region is covered with thick vegetation due to its composition of both low and high jungle. The region is regularly humid as it rains year round and is warm with temperatures ranging from 60°F to over 100°F. The climate in Loreto is determined by the Andes Mountains that run diagonally through Peru, concentrating the rainfall. Regions are separated into provinces and provinces into districts. The Loreto region is separated into seven provinces. The province in which this study takes place is in the Maynas province and in the districts of Fernando Lores (Tamshiyacu) and Punchana

(Figure 2). This region is very poor due to its geographical isolation, leading to poor development and health documentation (Dean, Valdeavellano, McKinley, & Saul, 2000). There is 66.3% of the population that is considered poor and live below the poverty line (Newman & Shapiro, 2010).

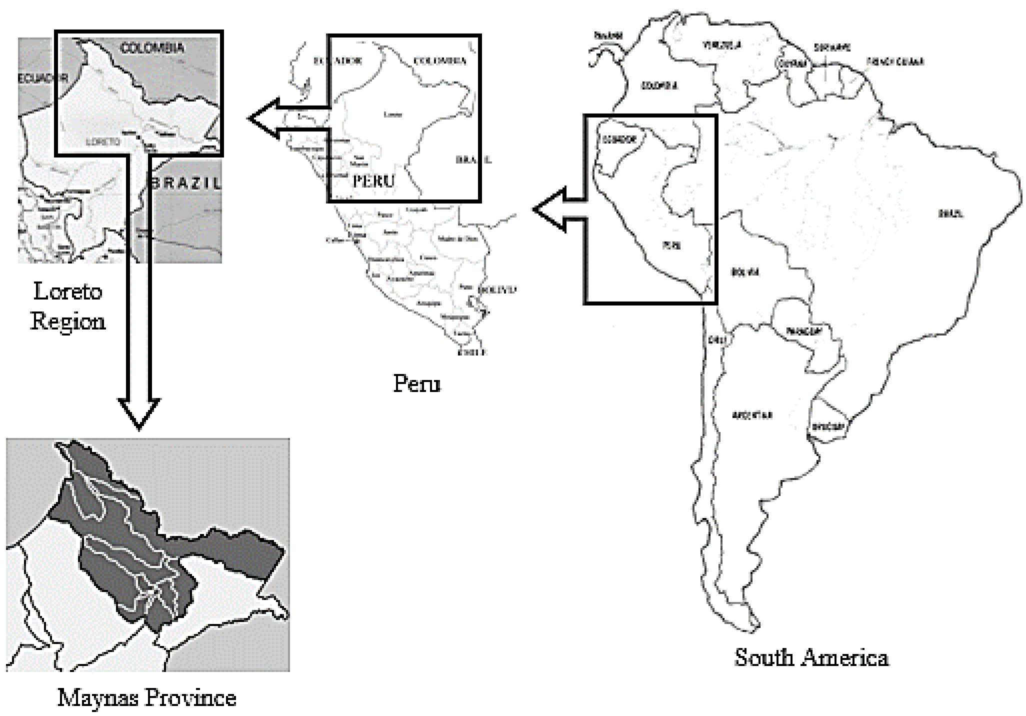

Figure 2. Localization of the Maynas province within the Loreto region of Peru.

Peru's Health Infrastructure

General health infrastructure.

Globally, 4 billion people do not have access to modern communication services, 1 billion lack access to roads, 2.3 billion lack reliable energy sources, 1.2 billion lack access to a source of safe drinking water, and 2.4 billion lack sanitation facilities (Global Poverty Project, 2004). Deficiencies in traditional and health infrastructures adversely influence wellbeing. Peru has recently experienced a surge of economic growth and is developing its current healthcare system by decentralizing it. The decentralized system is a universal health coverage (UHC) plan called Seguro Integral de Salud (SIS); a system coupled with responsible budgeting and planning to strengthen capacity, promote equity, efficiency, and ensure high quality care (Chenomics, n.d.; Universal Health Coverage, n.d.; Valdivia, 2002). SIS was implemented upon the country's return to democracy in 2001 and was aimed at eliminating user fees, "a major economic barrier in health service access," as well as providing a mechanism for public health care and drug delivery (Francke, 2013, p. 2). Peruvian health care is administered by five sectors including the 1) Ministry of Health (MoH), 2) EsSalud, 3) Armed Forces (FFAA), 4) National Police (PNP), and 5) the private sector. The MoH is directly overseen by the government so it has most of the responsibility for the country's health care sector and is charged with ensuring satisfactory health to all citizens (Global Surance, 2013). EsSalud is national employment-based coverage for the working class, the FFAA and PNP provide for military and police, and the private sector covers more than just basic care for those that can afford it.

The increasing population and rapid urbanization in Peru has stressed the public service infrastructure as well as the provision of environmental and public health services (Baffigo et al., 2001). Rural jungle villages have a lack of access to health care, largely because they cannot afford the travel, medications, or the appointment. Despite the billions spent on social programs and years of promises, of the poor, it is estimated that 20% live in absolute poverty living on less than one U.S. dollar a day (Advameg, 2013). The income distribution is skewed, further widening the inequalities between the rich and poor as the top 10% controls the majority of the nation's wealth (Appendix B) (World Bank, 2013).

The geographic distribution of the workforce is highest in coastal areas and larger cities such as Lima (30%), with rural regions having the lowest distribution (25%) (Arroyo et al., 2011;

Francke, 2013). Within the Peruvian UHC is a plan to "distribute and retain health workers in remote areas" which has started to help alleviate urban/rural density differences (Global Health Workforce Alliance, 2013). Nursing, general practice physicians, and public health professionals are of increasing demand, but many are seeking out other employment to increase their income. Many doctors have to work several jobs in both the private and public sectors to make ends meet. Dr. Marvin, a Peruvian general practice physician said that jobs are hard to find, even for a doctor in Peru (Dr. Marvin Barreto Mostacero, personal communication, May 24, 2010), and many work jobs similar to an American EMT-Paramedic.

Healthcare in Loreto.

Rural communities have extremely limited access to services, especially in the Amazon where services are largely unavailable, poorly orchestrated, and unmonitored (Dean et al., 2000). In the Loreto region, the majority of the department's health infrastructure is located in Iquitos, the region's capital, and Nauta, a small city on the bank of the Amazon; these two cities do not meet the needs of the territory.

In rural areas of the country, the government has built and established 'postas' or health posts; such posts are physical buildings, but they are rarely staffed, supplied, or regulated (K. Rosenquist personal communication, May 6, 2013). Overall, there is insufficient public medical care as a quarter of the Peruvian population does not have access to consistent and accessible health care services (Vital Wave Consulting, 2009).

Healthcare in the small villages is usually non-existent, but there are traveling health promoters that give talks on transmission of disease, hygiene, nutrition, and newborn care (Hewett & Duggan, 1986; Dean et al., 2000), and there are traveling nurse midwives assigned to certain regions who travel to deliver babies (R. Ferguson personal communication, May 6, 2013). The government also supports nurses who come out to rural areas to vaccinate communities. Occasionally government-run free clinics take place in larger villages and cities to cater to the poor, providing family planning methods such as birth control shots and basic health education.

Medications.

Traditionally, Peru’s health infrastructure has been concentrated in the richer urban areas (Valdivia, 2002). The government-supported ‘postas’ occasionally have some medications, but they are expensive and the variety is always lacking. In 2006 the Health Action International’s Coordinating Office for Latin America and the Caribbean (AIS-LAC) surveyed Peruvian price and availability for drugs and medicines on the Essential Medicines List of Peru. They determined that the median availability was 0% in public facilities and that the private sector brands cost 28 to 75 times the international reference price (Meza, 2007). Affordability is a major concern because cumulative costs for some medicines exceed 100% of their market value in the public sector, and can exceed 200% in the private sector (Meza, 2007). Even basic medications for treating simple infections are not available. There aren’t many medication regulations in Peruvian pharmacies. Most of what is considered an American ‘controlled substance’ is largely accessible over the counter if it is affordable. “Patients face problems in getting the right medicines at the right time for the right price” (Portillo, n.d., p. 1). People try to obtain most of their care outside of the hospital or clinic to save money. The costs for consultations and drugs should be examined because, for the poor, they are economic barriers to the utilization of health services (Valdivia, 2002). The WHO suggests that a well-functioning health system seeks to protect people against the financial consequences of ill-health.

Customs & cultural norms.

The social customs and cultural norms of those that come into jungle clinics can be unfamiliar. Men traditionally do not go to clinics because they are working in the fields or are taking shipments of logs to Iquitos to sell. It is generally women who bring their children, some youth, and the elderly. Peruvian men largely suffer without medical attention until the health issue is more advanced. A traditional health infrastructure exists in the Peruvian jungle. Most people first seek out homeopathic or traditional medicine from a curandero (traditional healer) or a brujo (witch doctor) (Bussmann & Sharon, 2006; Hewett & Duggan, 1986). The efficacy of traditional medicine is higher than conventional medicine, and it is also 53-63% cheaper (Bussmann & Sharon, 2006).

Many people seek out brujos because they have a belief in ‘curses’ and spiritual causes of physical illness (K. Rosenquist personal communication, June 1, 2013). In some traditional medical ceremonies done by brujos, they utilize a potent hallucinogenic drug called ahuayasca. This drug is translated as ‘Vine of the Soul,’ and often referred to as ‘La Medicina’ or ‘The Medicine’ by the local populous. It has been proposed as a cure for cancer and other illnesses (Paramaguru, 2012; Miller, 2006; McKenna, 1998; Kilham, 2011; Jambusarwalla, 2012; Riba et al., 2003).

Importance of medical volunteerism.

U.S. medical providers have an increased interest in volunteering overseas because their actions significantly affect forces that determine global health. In 1984 only 6% of graduating U.S. and Canadian medical students had participated in an international health elective, whereas in 2004, the percentage increased to 22% (Suchdev et al., 2007). It is estimated that approximately 6,000 short-term U.S. medical volunteer trips to countries globally occur annually. A conservative estimate is that more than $250 million are spent per year (Maki, Qualls, White, Kleefield, & Crone, 2008). The impact of these trips is unsurpassed as participation in medical volunteerisms in underserved communities around the world is a valuable service, but quality and limits need not be compromised. It is unethical to practice outside one's scope of practice whether in a high-income, middle-income, or low-income country as the forum on Education Abroad states that people should "not engage in activities beyond their education level" (Fischer, 2013, p. 1; Santmyire, 2013). Projects that do not apply best practices and do not think about sustainability undermine the local health infrastructure, reinforce poverty, and cause significant harm (Pinto & Upshur, 2007). The Children's Health International Medical Project of Seattle (CHIMPS) has a mission statement that is: "To ethically address underlying health issues and to provide sustainable public health interventions and medical assistance for underserved communities in developing countries," which supports the common vision of many volunteer health professionals (Suchdev et al., 2007, p. 318). Improving services in providing education, relief, and awareness produces greater sustainability and growth of volunteer health efforts (Alghothani, Alghothani, & Atassi, 2012).

IPI Prevalence

Global IPI prevalence.

IPI distribution depends on their physical and biological environments as well as human behavior. Because many parasitic lifecycles require warm weather for host to host transmission, IPIs are found more prevalently in temperate and tropical regions. The impacts of these infections are more significant in low- and middle- income countries where they contribute to greater economic impact, morbidity, and mortality. Such countries are most affected by IPI diseases for a number of reasons including cultural and region-specific risk factors. IPIs contribute to malnutrition, growth retardation, anemia, dehydration, and respiratory problems among other health issues.

Common intestinal parasites are eukaryotic worms labeled as helminthes, and unicellular plant- and animal- like eukaryotic protozoans. The most frequent intestinal parasites include *Giardia lamblia, Cryptosporidium parvum, Toxoplasma, Entamoeba histolytica, Cyclospora cayetanensis, Hymenolepsis diminura, Hymenolepsis nana, and Ascaris lumbricoides* (Table 1) (Mackay & Chiodini, 2003; Cordova Paz Soldan et al., 2006; Moraes Neto et al., 2010). Leishmaniasis and Schistosomiasis are also competing significant worldwide infections considered by the WHO (Almeida & Santos, 2011). *Ascaris lumbricoides* is the most frequent intestinal parasitizing soil-transmitted helminth worldwide, infecting about one billion individuals (Moraes Neto et al., 2010). *Giardia lamblia* is the most prevalent intestinal parasitizing protozoan worldwide, currently infecting 200 million and is the cause of 2.8 billion infections annually (Hollm-Delgado et al., 2008; Moraes Neto et al., 2010). *Giardia* is common among children and travelers, especially in hyperendemic countries like Peru, and morbidity is usually limited to early childhood (Hollm-Delgado et al., 2008).

Peruvian IPI prevalence.

Infectious diseases are among the leading causes of death in Peru, and IPIs are in the top ten leading causes at approximately 7.7% of the disease burden (Karesh et al., 2012). Diarrheal disease prevalence is high in rural children as cholera is endemic in Peru and is a factor leading to the 40.6% chronic malnutrition rate in rural areas of the country. Communicable diseases, especially those that are respiratory in nature are significant problems in Peru. Changes in land use due to mining, logging, plantation development, and oil and gas extraction pose a significant global health threat because tropical regions are emerging disease hotspots (Baker et al., 2010;

Karesh et al., 2012). Generally IPIs are endemic to the poorest communities in developing countries with weak health infrastructures, and are linked to a lack of safe water, sanitation and improper hygiene which are also major contributors of 90% of IPI deaths (Solomon et al., 2012; Moraes Neto et al., 2010; Reingold & Gordon, 2012). Disease incidence in people can drastically increase as the abundance of the preferred animal hosts decrease (Karesh et al., 2012). In a longitudinal study by Hollm-Delgado et al. (2008), it was determined that of the study children in Lima, Peru, 85% became infected with Giardia, and 87% of those became reinfected over the four year time period. This research supports the fact that IPIs are significant pathogens in hyperendemic developing countries, even in the most developed regions. In Lambayeque, Peru, it was found that 83.5% of the studied population had a current IPI that may or may not have been associated with positive serology results (Espinoza et al., 2008).

IPI prevalence in Loreto, Peru.

Recent economic growth has not helped the poorest and remote Peruvian citizens who continue to suffer from acute health challenges of infectious diseases, lack of immunizations, and lack of primary health care services (Vital Wave Consulting, 2009). In a Brazilian study done by Moraes Neto et al. (2010), in a region with similar infrastructure and social determinants as Loreto, found that 38.5% of the population was parasitized. Due to the lack of data for the Peruvian Loreto region, IPI transmission and prevalence rates are likely to be similar to those of Brazilian Amazon. It was pointed out by Smillie and Augustine (1925) that it is the intensity, not the incidence of an infestation that determines the seriousness of the problem. Significantly, it was reported that 93% of examined individuals in the largest jungle city of Iquitos, Peru, had a patent IPI. Of the studied children, there were heavy IPI infestations as 75% had Ascaris, 91% had Hookworm, 81% had Trichuris, and 31% had protozoan cysts (White et al., 1957). In another study done in the Peruvian Amazon, a lack of sanitation and contaminated water led to an incidence rate for IPIs at almost 100% in the 1950s and 60s. Upon further investigation of current disease rates, health promoters made a 40% diagnosis for the relative prevalence of gastrointestinal disease caused by IPIs (Hewett & Duggan, 1986). The WHO (2007) suggests that a well-functioning health system seeks to defend the population against what threatens its health, and the rural Peruvian population is threatened by many infectious disease risks.

Types of Transmissive Sources

Water and food-linked transmission.

Inadequate sources of drinking water and contaminated food are major routes of transmission for intestinal parasites. According to the WHO, unsafe water in developing countries accounts for 80% of their burden of disease (BOD). Water is a major source of parasitic disease transmission as there are currently one billion people without access to safe water causing two billion cases of diarrhea per year (World Water Day, 2011). Common infections spread this route are *Giardia, Cryptosporidium,* and *Acanthamoeba histolytica.*

Slifko, Smith, and Rose (2000) reported that in the United States, parasitic diseases cause approximately 2.5 million foodborne illnesses annually. It is also reported that 3.4 million people, mostly children, die annually from water-related diseases (World Water Day, 2011). This highlights the fact that even in a high-income country IPIs pose a significant health risk. In a study done by the Johns Hopkins Bloomberg School of Public Health, *Giardia* was a significant infection on Peruvian children; they found that of 220 study participants over a period of four years, 85% became infected and 87% of those became re-infected. It was determined that malnutrition exacerbated an infection, and that infection did not cause diarrhea or child growth inhibition (Hollm-Delgado et al., 2008).

In rural Brazil it was found that unsafe drinking water was a significant source of IPIs. It was noted that because of the lack of sanitation, water supplies were getting infected by sewage. This possibly contributed to a 50% parasite prevalence rate in the study (Moraes Neto et al., 2010). Another study focused on *Cryptosporidium* as a predominant infection in Peru that Cordova Paz Soldan et al. (2006) found was a significant cause of diarrhea, malnutrition, nausea, and vomiting. It was also determined that 91.2% of Puno, Peru was intestinally parasitized. The study looked into food sources and water supplies, and found that those were major routes of transmission. Although water is the most significant source of transmission, undercooked and surface infected meat, fruits, and vegetables are other sources.

Sanitation and hygiene-linked transmission.

Poor sanitation and hygiene has been a major source of disease transmission that is more common in rural and periurban communities. Of the world's seven billion people (Population Reference Bureau [PRB], 2013), it is estimated that 40% lack acceptable means of sanitation (Schlein, n.d.) leaving 2.6 billion people at risk for IPIs. As referenced in Appendix C, Peru is below the world average for percent of the population with no access to sanitation with 31-50% falling into that category (Global Poverty Project, 2004). A lack of awareness about hygiene, overcrowding, improper plumbing, animal contact, and inadequate disposal of refuse promote the spread of disease (Moraes Neto et al., 2010). In a study by Baffigo et al. (2001), rapid urbanization and stressed or non-existent public service infrastructure lead to environmental transmissive routes for IPIs. They also described that 92% of the studied wells were infected by coliforms which contributed to illness. With increasing population density, 2.5 billion people are left without access to proper sanitation, leaving the poor with increasing mortality due to IPIs (Frieden, 2010). Complex interactions between the environment, parasites, and hosts, along with precarious domiciliary and peridomiciliary living conditions increase IPI exposure and transmission (Moraes Neto et al., 2010).

Zoonotic-linked transmission.

Humans and animals share environmental locales, therefore, they can be accidental, intermediate or final parasite hosts, which can be transmitted through contaminated food or water, or directly in intermediate stages through animal zoonoses (Slifko, Smith, & Rose, 2000). Domestic, wild, captive, and companion animals are possible infective agents due to poor hygiene or sanitation (Ramirez, Ward, & Sreevatsan, 2004). Approximately 20% of adult dogs and 90% of puppies have patent IPIs (Slifko et al., 2000). More than 60% of 1,700 diseases seen in humans originated in wild or domestic animals, contributing to millions of deaths and billions ill yearly (Karesh et al., 2012; Ramirez et al., 2004). Flies are a commonly overlooked zoonotic transmissive source as they ingest 1 to 3mg of parasite-infected feces over a few hours and can transmit ova and cysts internally or externally through bites or food (Almeida & Santos, 2011; Moeller, 2011; Slifko et al., 2000).

Table 1. *Some Parasitic Diseases and Their Relationships to Water, Food, Sanitation, and Zoonotic Sources*

Order	**Genus**	**Species**	**Transmission**	**Transmissive Sources**	**Contamination**	**Related Questions**	**Reservoir**	**Treatment**
Vestibuliferida	*Balantidium*	*B. coli*	Ingestion of cysts.	Water, Food, Sanitation, Zoonoses	Fecal-oral, Contaminated food & water	1-8, 11, 13	Swine, Rats, Primates, Humans	Tetracycline, Ampicillin, Bacitracin, Iodoquinol, Metronidazole, Paramomycin
Eucoccidiorida	*Cryptosporidium*	*C. parvum*	Ingestion of cysts.	Water, Food, Sanitation, Zoonoses	Fecal-oral, Person-to-person, Animal-to-person, Contaminated food & water	1-8, 11, 13, 14, 17	Humans, Cattle, Domesticated & feral animals	Nitazoxanide, Paromycin, Azithromycin
Eucoccidiorida	*Cyclospora*	*C. cayentanesis*	Ingestion of spores.	Water, Food	Fecal-oral, Contaminated food & water	1-5, 8, 11, 13, 17	Humans	Trimethoprim-sulfamethoxazole, Ciprofloxacin
Amoebida	*Entamoeba*	*E. histolytica*	Ingestion of cysts & trophozoites.	Water, Food, Sanitation	Fecal-oral, Contaminated food & water	1-5, 8, 9, 11, 12, 16	Humans, Primates	Asymptomatic: Diloxanide Furoate, Clefamide, Etofamide, Paromomycin, Teclozan. Symptomatic: Metronidazole, Tinidazole, Ornidazole
Diplomonadida	*Giardia*	*G. lamblia*	Ingestion of cysts	Water, Food, Sanitation, Zoonoses	Fecal-oral, Oral-anal, Person-to-person, Animal-to-person, Contaminated food & water	1-8, 11, 13, 14, 17	Humans, Cats, Dogs, Birds, Cattle, Beavers, Deer, Sheep	Metronidazole, Tinidazole, Nitazoxanide, Albendazole, Paromomycin, Furazolidone, Quinacrine
Microsporida	*Enterocytozoon*	*E. bieneusi*	Environment resistant spores. Vertical and horizontal transmission.	Water, Food, Sanitation, Zoonoses	Fecal-oral, Oral-oral, Contaminated food & water, Contaminated soil	1-8, 11, 13	Pigs, Fish, Cattle, Primates, Humans	Albendazole

Table 1. *Some Parasitic Diseases and Their Relationships to Water, Food, Sanitation, and Zoonotic Sources (continued)*

Order	**Genus**	**Species**	**Transmission**	**Transmissive Sources**	**Contamination**	**Related Questions**	**Reservoir**	**Treatment**
Oligacanthorhynchida	*Macracanthorhynchus*	*M. hirudinaceous*	Ingestion of eggs or embryonated larvae that are environmentally resistant	Water, Food, Sanitation, Zoonoses	Fecal-oral, Animal-to-person, Contaminated food & water, Contaminated soil	1-8, 10-16	Swine, Dogs, Primates, Humans	Pyrantel Pamoate
Ascaridida	*Ascaris*	*A. lumbricoides*	Ingested fertilized eggs	Food, Animals, Sanitation	Fecal-oral, Contaminated food, Contaminated soil	4-6, 8, 10-12, 15	Humans	Mebendazole, Albendazole, Ivermectin, Pyrantel Pamoate, Levamisole
Strongylida	*Necator*	*N. americanus*	Infective filariform larval skin penetration	Sanitation	Fecal contamination leading to larval skin penetration, Contaminated soil	6, 7, 9, 11, 12, 15, 17	Humans, possibly swine	Albendazole, Mebendazole, Pyrantel Pamoate
Cyclophyllidea	*Hymenolepsis*	*H. nana*	Ingestion of eggs	Water, Food, Sanitation	Contaminated food & water, Person-to-person, Insect-to-person through ingestion, Contaminated soil	1-5, 8, 11, 13, 15, 17	Humans, possibly mice or rats	Praziquantel, Niclosamide, Nitazoxanide
Strigeidida	*Schistosoma*	*S. mansoni*	Cercaria larval skin penetration	Water	Fecal-oral, Contaminated food & water, Contaminated soil	1-3, 5, 10-13, 15	Humans, Snails	Praziquantel, Oxamniquine, Metrifonate
Rhabdtida	*Strongyloides*	*S. stercoralis*	Infective filariform larval skin penetration	Sanitation	Autoinfection, Person-to-person, Fecal contamination leading to larval skin penetration, Contaminated soil	6, 7, 9, 10-15, 17	Humans, Cats, Dogs, Primates	Ivermectin, Thiabendazole, Albendazole
Trichocephalida	*Trichuris*	*T. trichiura*	Ingestion of infective eggs	Food, Water, Sanitation, Zoonoses	Pica, Contaminated food, Contaminated soil	1-5, 6, 8, 9, 11-13, 16	Humans, possibly Cats & Dogs	Albendazole, Mebendazole

Notes. 1) The questions being referenced in the 'Related Questions' section are from the risk factor questionnaire that can be found in Appendices E and F. 2) The table is adapted from Slifko et al. (2000). 3) Data for Microsporida collected from Mathis, Weber, and Deplazes (2005), for Strongylida from Steenhard, Storey, Yelifari, Pit, and Nansen (2000), and all other information from Heymann (2008).

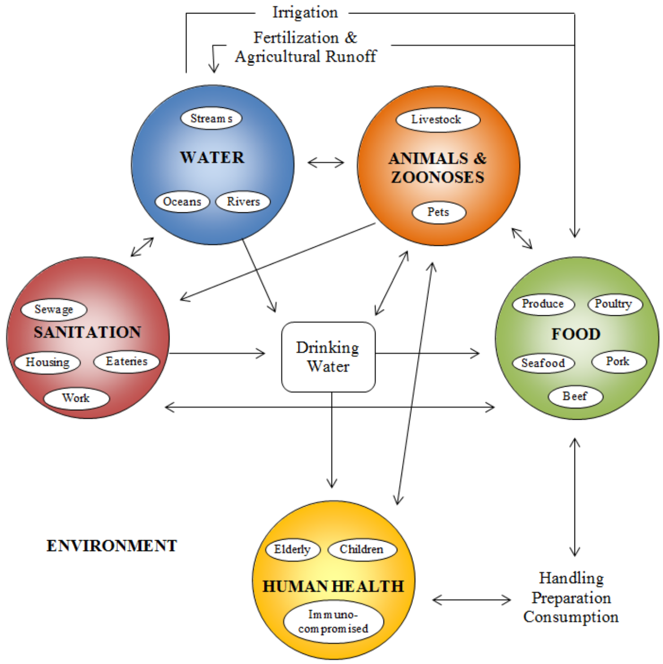

Figure 3. Complexities of IPI transmissive sources and their connection to human health and the environment.

Note. Figure adapted from Slifko et al. (2000).

Statement of Purpose

There are many factors which are responsible for poor health status leading to significant morbidity and mortality due to IPIs, and this study sought to explore those risk factors. The IPI prevalence, lack of health infrastructure, and limited health education in the rural Loreto region of Peru were explored. Demographic and socioeconomic status, health characteristics, as well as practices and behaviors were analyzed in clinic patients to determine their relationship to intestinal parasitic diseases. For future preventive interventions to be implemented, this research will help determine common IPI risk factors and culturally acceptable intervention strategies.

Materials and Methods

The study included the following components: 1) data collection using a three-part survey exploring demographic and socioeconomic factors, health characteristics, as well as practices and behaviors; 2) clinical assessment ascertaining the health and presence of IPs; 3) descriptive characteristics of the four study villages; and 4) analysis using chi square and attributable risk calculations for IPI risk factors.

Study Area and Population

The data was collected over a study period of three weeks during a short-term medical research trip in May of 2013. It was supported and organized by the missionary sending agency, Global Partners, in partnership with The Rural Amazonian Health Initiative – Peru. In this rural Peruvian study, data was obtained from four locations; three within the Fernando Lores (Tamshiyacu) district: Santa Ana, Tapira Zone 1, and Tapira Zone 2; and one village in the Punchana district: San Juan de Sinchicuy. The study villages were all located off of small tributaries of the Amazon River near Iquitos, the capital city of the Loreto region. Each of the four locations visited differed by socioeconomic status, demographic characteristics, means of employment, and health features.

Table 2
Characteristics of Village Infrastructure

Village	**Santa Ana**	**Tapira Zone 1**	**Tapira Zone 2**	**San Juan de Sinchicuy**
Sidewalks	Yes	No	No	Yes
Paved Streets	No	No	No	No
Sturdy Construction	Yes	No	No	Yes
Schoolhouse	Yes	Yes*	Yes*	Yes
Farm Animals	Yes	No	No	Yes
Clean Water Well(s)	No	No	No	Yes
Sewer System	No	No	No	No
Outhouse(s)	Yes	No	No	Yes
Garbage Collection	No	No	No	No

Note. ***** Tapira Zone 1 and Tapira Zone 2 share a schoolhouse

Questionnaire Development

There is no currently standardized questionnaire available that focuses on risk factors related to IPIs, therefore, the questionnaire used in this study was developed specifically for the rural Peruvian population as identified in literature and corroborated by public health and medical professionals. Survey data was collected as three components (Figure 4); 1) features of demographic and socioeconomic status, 2) health characteristics, and 3) risk factor practices and behavior assessment. The surveys were offered in both English (Appendix D) and Spanish (Appendix E) versions.

Figure 4. Flowchart for components of data collection and survey design.

Demographic and socioeconomic status.

The demographic and socioeconomic status component of the survey captured data on age, date of birth, gender, number of people per household, number of children under five per household, home village, occupation, literacy, and scholarity. Scholarity refers to the highest education attained whereas literacy refers to reading and/or writing proficiency.

Health characteristics.

The health characteristic component of the survey collected information on patient medical history, symptom observation, physical exam, assessment, and treatment. The medical professionals were asked to focus the record of chief complaint and physical exam on select factors presented in literature. Clinical signs and symptoms for IPIs including respiratory problems, hepatomegaly, splenomegaly, abdominal pain, pruritus, and chronic weakness (Espinoza et al., 2008), as well as acute diarrhea, nausea, and vomiting (Cordova Paz Soldan, et al., 2006) were considered in survey development. Clinical questions were further developed based on findings presented in Appendix I, referring to multiple different gastrointestinal parasites of interest and their effects on human hosts.

Practices and behaviors.

Questions developed for the practices and behavior assessment were grounded in literature findings, as well as on clinical risk factors for disease acquisition related to IPI lifecycles. The questions assessed fell into five broad categories including: access to a source of safe and potable water, food safety, sanitary conditions, proximity to animals, and symptoms of IPI. Practices regarding the consumption of undercooked or raw vegetables, cured, pickled, undercooked or air-dried meat, as well as perception of health, dehydration, and weight loss were included in the questionnaire (Slifko, et al., 2000). Ownership of pets, their presence within the home, and history of geophagia or pica, were also considered as follow-up questions (Espinoza et al., 2008).

Clinic Layout

At each of the four village locations, temporary primary care clinics were held. Each clinic had five stations including: triage, pharmacy, dental, medical, and vision. At the triage station, a qualified and trained nurse collected demographic information, medical history, clinical presentation, and treatment data. The pharmacy station dispensed medications. At the dental station, severely decayed teeth were extracted, and patients were counseled on proper oral hygiene. At the medical station, medical professionals provided physical assessment and prescribed medications. Lastly, at the vision station patients were fitted for prescription eye glasses.

Process of Data Collection

It was explained to the participants that their information would be used to assess how parasite risk factors have an impact on their health and that they were not obligated to participate in order to receive care. As most patients were illiterate, consent was obtained verbally for all participants by the triage nurse or principal investigator who recited and explained instructions from a provided form. Verbal instructions covered the survey process, reason for data collection, and lack of risk before proceeding with the questionnaire. Every third patient being seen in the triage station of each clinic was invited to participate in the data collection. The triage station was separated from other patients exhibiting a private environment for giving consent and obtaining data. Ethical approval was obtained from Wright State University Institutional Review Board (IRB) (Appendix F), and from David Scott on behalf of Global Partners (Appendix G).

Treatment of Parasitized Individuals

The drugs used for treatment were purchased from Medical Assistance Program (MAP) International and from an Inka Farma pharmacy in Iquitos. Every patient that presented with the signs and symptoms of an IPI were clinic-treated by medical professionals. The treatment protocol was as follows: individuals that were parasitized by IPIs were given three 400mg doses of albendazole and were instructed to take one per day for three days. In addition, pregnant women were given pre-natal vitamins and iron supplements.

Data Management and Statistical Analysis

During the data collection process, completed questionnaires were regularly checked to rectify discrepancies or missing values. Information was recorded on hard copies and were entered in an EXCEL spreadsheet (Microsoft Office 2007 for Windows). The hard copies were kept in a locked box and were completely deidentified. Each patient was issued a randomized identification number and names were discarded. Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 15.0.

Based on socioeconomic status, the populations of the four villages were categorized in two groups, group one was the population from the MP villages of Santa Ana and San Juan de Cinchicuy, and group two comprised of the VP villages of Tapira Zone 1 and Tapira Zone 2.

Categorical data was described using proportions and frequencies. Continuous variables were summarized as sample means, and standard deviations. Pearson's Chi-Square test was used to analyze statistical significance between categorical variables, and two sample t-test was used to analyze continuous variables across the two categories of villages (MP and VP, respectively). Statistical significance was set at $p < 0.05$. Two by two tables were run to calculate odds ratios, risk ratios, and 95% confidence intervals to assess associations between IPI status (positive, negative) and risk factors (gender, education, literacy, as well as access to safe water, food, and sanitation). Attributable risk (AR), attributable risk percent (AR%), population attributable risk (PAR), and population attributable risk percent (PAR%) calculations were run to determine the prevalence risk of IPI infection.

Results

Village Infrastructure

The village of Santa Ana is an upper-low-income village that has cement sidewalks, a government-built cement schoolhouse, and domiciles made with lasting construction with building materials of timber, brick, and concrete (Figure 5a). Tapira Zone 1 and Tapira Zone 2 are on the lowest end of the low-income spectrum as the houses are dilapidated, made of sticks and scraps of tin, and the roads are trails and clearings amidst jungle foliage. However, they do have a government-built cement schoolhouse (Figures 5b, 5c). The village of San Juan de Sinchicuy is more of a middle-low-income village that has well-built wooden homes with thatched roofs, a government-built cement schoolhouse, cement walkways, a variety of farm animals, and several clean water wells (Figures 5d, 5e). None of the four communities had garbage collection or sanitary infrastructure of a sewer system although Santa Ana and San Juan de Sinchycuy did have outhouses (Figure 5f). All communities except for San Juan de Sinchycuy lacked a source of clean, potable water as their primary water supply was directly from the river.

Figure 5 a-f. Overview of the Santa Ana, Tapira Zone 1, Tapira Zone 2, and San Juan de Sinchicuy communities from the Maynas and Punchana districts of the Loreto region of Peru. **a, f** Santa Ana village: has good infrastructure with paved walkways and sturdy buildings; they have some outhouses, but have no clean water supply. **b, c** Tapira Zones 1 & 2 communities: have no streets or real infrastructure, the dwellings are, for the most part, improvised and of flimsy, makeshift materials which provide minimum protection and comfort. **d, e** San Juan de Sinchicuy village: has an impressive amount of infrastructure for a rural village; dwellings are made of solid and lasting construction materials; there are several clean water wells.

Village infrastructure. Photo credit: Jonathan Stofer. May 2013.

Demographic and Socioeconomic Status

When comparing demographic and socioeconomic characteristics between MP and VP villages, it was determined that age, scholarity, and literacy were significantly different ($p < 0.05$) (Table 3). In the MP villages, the 10-35 year age group was significantly higher than in the VP villages (45% and 22%, respectively). MP villagers were significantly more educated than the VP villagers (MP: 17%, VP: 37%). Half of the VP village members were illiterate, unable to read or write, in comparison to 22% of the MP village members ($p = 0.003$). Analyses regarding preventable risk in the population due to IPIs showed that contributing factors of gender, education, literacy, and transmission routes did not show any significant association (Table 4). Of the total 120 study participants, 78 were identified as intestinally parasitized leading to an overall prevalence rate of 65%, or every 6.5 out of 10 clinic patients were considered at risk for an IPI (MP: 54%, VP: 76%).

Table 3

Demographic and Socioeconomic Profile for MP and VP Communities

Aspect Evaluated	**Answer**	**MP (%) n = 60**	**VP (%) n = 60**	**P-value**
Age Group	0 to 9	14 (23)	25 (42)	
	10 to 35	27 (45)	13 (22)	0.016*
	≥36	19 (32)	22 (37)	
Gender	Male	21 (35)	27 (45)	0.264
	Female	39 (65)	33 (55)	
Number of People in Household	1 to 3	13 (22)	13 (22)	
	4 to 6	32 (53)	34 (57)	0.903
	≥7	15 (25)	13 (22)	
Scholarity	None	10 (17)	22 (37)	
	Primary School	40 (67)	32 (53)	0.041*
	High School & Higher Education	10 (17)	6 (10)	
Literacy	None	13 (22)	30 (50)	
	Read	1 (2)	0 (0)	0.003*
	Write	0 (0)	2 (3)	
	Read and Write	46 (77)	28 (47)	
Occupation **	External (Out-of-town)	14 (24)	16 (28)	
	Domestic (Local)	21 (36)	12 (21)	0.197
	Other	24 (41)	30 (52)	

Note. * Significant values; $p < 0.05$; Column %

** n for the occupation variable is MP= 59 and VP= 58

Table 4

Preventable Risk Pertaining to Intestinal Parasitic Infections

Aspect Evaluated	**Characteristics**	**Total Patients n= 120**	**Total Positive for IPI n= 78**	**Odds Ratio**	**95% Confidence Interval**	**Risk Ratio**	**95% Confidence Interval**	**Attributable Risk**	**Attributable Risk Percent (%)**	**Population Attributable Risk**	**Population Attributable Risk Percent (%)**
Gender	Male	48	35	1.82	0.77, 4.33	1.22	0.91, 1.57	0.132	18.1	0.053	8.12
	Female	72	43								
Education	None	32	21	0.98	0.41, 2.25	1.01	0.92, 1.12	0.009	1.30	0.002	0.35
	Some	88	57								
Literacy	Read and/or Write	77	52	1.36	0.58, 3.17	1.12	1.01, 1.23	0.071	10.5	0.045	6.98
	None	43	26								
Trans-missive Sources	Best	60	41	1.34	0.59, 3.05	1.11	1.01, 1.21	0.067	9.76	0.033	5.13
	Worst	60	37								

Note. An insignificant association between preventable risks and IPI prevalence was observed.

Health Characteristics

The primary chief complaint of patients from both MP and VP villages was ‘parasites and gastrointestinal symptoms’ (68% and 62%, respectively) (Appendix A). The physician medical exam collected information as two components between MP and VP villages (Table 5). Component A comprised of assessment and treatment between the two village categories, and Component B comprised of IPI symptoms as reported by positively diagnosed patients. In regard to assessment, VP villages had a higher proportion of patients with IPIs and gastrointestinal disease (MP: 54%, VP: 76%) (Table 5A). Of all IPI positive patients, symptoms experienced were similar across both village categories (Table 5B).

Table 5

A. Physician Medical Exam for Residents from MP and VP Communities

Aspect Evaluated	**Answer**	**MP (%) n = 60**	**VP (%) n = 60**	**P-value**
Assessment	Parasites / Gastrointestinal Disease	33 (54)	45 (76)	0.022*
	Respiratory & Circulatory Disease	11 (18)	6 (10)	0.190
	Other	16 (27)	9 (15)	0.120
Treatment	Antiparasitics	40 (67)	44 (73)	0.190
	Other	20 (33)	16 (27)	0.559

Note. Significant Values; $p < 0.05$; Column %

B. Symptoms of IPI Infection in Diagnosed Residents from MP and VP Communities

Aspect Evaluated	**MP (%) Yes**	**VP (%) Yes**	**P-value**
Persistent stomach bloating	23 (52)	21 (48)	0.705
Stomach cramps	15 (47)	17 (53)	0.680
Difficult and painful defecation	15 (65)	8 (35)	0.104
Persistent diarrhea (3 loose stools daily)	24 (55)	20 (46)	0.449
Nausea and/or vomiting	20 (53)	18 (47)	0.695
Parasitic worm passed in stool	55 (49)	57 (51)	0.464
Occasional bloody urine or stool	12 (43)	16 (57)	0.388
Persistent fatigue even with adequate sleep	24 (57)	18 (43)	0.251

Note. Significant Values; $p < 0.05$; Row %

Practices and Behaviors

When comparing practices and behaviors of MP and VP villagers presenting with IPIs, the characteristics of water, food, animals, and sanitation were evaluated. It was observed that the risk factors of: 1) obtaining drinking water from a river, 2) consumption of undercooked and/or raw meat, and 3) regular occupational exposure to animals were significantly different between the two village groups ($p < 0.05$) (Table 6). More MP villagers obtained their drinking water from a river than VP villagers (54% and 46%, respectively). It was identified that 70% more MP villagers consumed undercooked and/or raw meat than VP villagers ($p=0.008$). Significantly more VP members had regular occupational exposure to animals than MP members (MP: 37%, VP: 63%). Poultry were found to be the most prevalently owned animal, and more IPI positive patients owned chickens and ducks than IPI negative patients (53% and 27%, respectively) (Figure 5A). The home was the most frequent animal exposure location for all study respondents, and more IPI positive patients were exposed to animals at home than due to occupational exposure (59% and 47%, respectively) (Figure 5B).

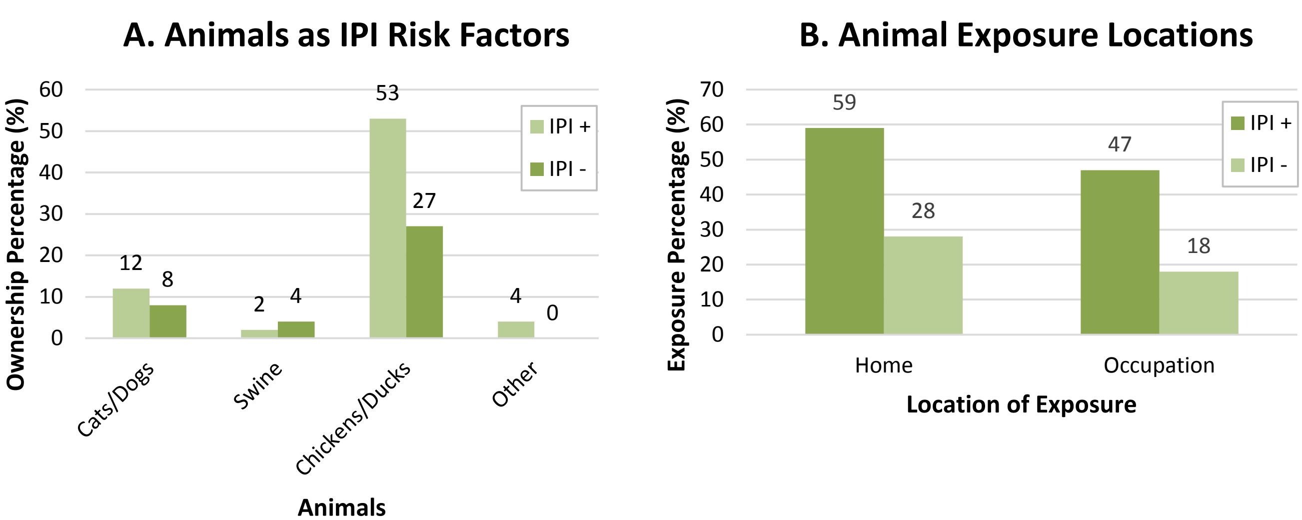

Figure 5. Distribution of animal species and exposure locations across four study locations as related to IPI diagnostic status.

Table 6
Practices and Behaviors of Villagers Presenting with an IPI

Aspect Evaluated	**MP (%) Yes**	**VP (%) Yes**	**P-value**
Water:			
Creeks and rivers used for hygiene and recreation	59 (52)	55 (48)	0.094
Drinking water from river	58 (54)	50 (46)	0.015*
River water consumed without boiling or filtering	38 (54)	32 (46)	0.267
Food:			
Consumption of unpeeled fruits and/or vegetables	13 (42)	18 (58)	0.297
Consumption of undercooked and/or raw meat	11 (85)	2 (15)	0.008*
Animal:			
Live animals in house	31 (46)	37 (54)	0.139
Regular occupational exposure to animals	20 (37)	34 (63)	0.001*
Sanitation:			
Hand washing before eating	60 (51)	58 (49)	0.154
Walking barefoot	16 (50)	16 (50)	1.000

Note. Significant Values; $p < 0.05$; Row %

Discussion

In this study, IPI prevalence, presentation, and relationship to transmissive routes were assessed among clinic patients from two very poor and two moderately poor communities in the Loreto region of Peru, South America. To our knowledge, this is the first study in rural Peru to investigate the relationship between IPIs and health status. The primary IPI transmission routes assessed were water, food, sanitation, and zoonoses.

Demographic and Socioeconomic Status

Economic, social, and environmental factors have a substantial effect on the health of a population (Frieden, 2010) (Appendix H). All four study villages studied were poor, lacking significant resources, necessary health structure, and had dwellings that are mostly improvised with minimum comfort. Peru is in a state of environmental health risk transition concentrating a significant burden of traditional risks, such as IPIs, on the rural inhabitants living in the Peruvian Amazon. In addition to traditional risks, Peru's health system is rudimentary in rural areas of the country, leading to significant rates of disease in affected populations (Gyapong et al., 2010; Francke, 2013).

IPIs were exhibited in 65% of the clinic patients with VP villages contributing to higher rates of infection. Collected data described that the two MP and VP village groups have similar gender distributions, and that MP villages had a greater proportion of working class. This finding is expected because the MP villages have significantly higher education and literacy rates which contribute to the better infrastructure characteristics. Occupational exposure to IPIs are expected to be higher in villages with more external occupations of logging, farming, and mining, but that correlation was not observed as both village groupings had similar occupational proportions. Findings for preventable risk pertaining to IPIs were not significant in this study, and differ largely from all other published research on IPIs (Moraes Neto et al., 2010; Llanos-Cuentas et al., 2008).

Health Characteristics

Health characteristics of vital signs, chief complaints, as well as physician assessment and treatment were collected to determine their link to IPIs. Vital signs above what is considered normal can be indicative of an infestation, but both MP and VP villages have means that fall within their normal ranges. When it comes to chief complaints, the MP villages presented with higher rates of 'parasites and gastrointestinal disease' complaints than the VP communities (MP: 68%, VP: 62%), which is possibly due to differences in education and primary knowledge about IPIs.

A common practice in the Peruvian Amazon is for people to shift between practitioners and from one type of healer to another, not always starting with the most appropriate option, but with what they can best afford and who they feel will be most effective given the severity of their problem (Scrimshaw, 2012). Medical volunteers are essential for filling in the gaps to provide treatment for patients that have barriers to health, such as financial stressors, confusion with the system, and insecurity of the right healer ideology. The Public Health Code of Ethics affirms that “humans have a right to the resources necessary for health” and sometimes short-term medical missions are required to deliver those resources (Public Health Leadership Society, 2002, p. 2). It is difficult in this type of setting without the use of Evidence Based Practice (EBP) to correctly diagnose each patient, however, in low- and middle-income countries, the practitioner must rely more on patient history, physical exam, and local health trends than an extensive imaging or laboratory testing because of obstacles that limit practicality (Santmyire, 2013). The patients diagnosed as IPI positive were treated with albendazole. It is deemed by Steinmann et al. (2011) that a single 400mg dose of albendazole is the most efficacious and ultimately just as effective as a triple dose of albendazole at treating patients with various IPIs, however the triple dose (the protocol used in the study) was found to cure a larger amount of *Taenia* infections.

Practices and Behaviors

Parasite practices and behavior questionnaire analysis of both village groups revealed that residents codified intestinal parasites differently, most frequent being “bichos,” “parasitos,” or “lombriz.” Members of all communities appeared adept in understanding the concept of intestinal parasites and answered appropriately in relation to parasite sources (contaminated water, lack of hygiene, barefoot, unwashed food) (Table 6). Survey analysis of both communities indicated that the residents had similar IPI risk factor exposures and presentations. An unusual finding was that more MP residents obtained their drinking water from the river than VP residents; however, this finding is inaccurate based on observation as well as according to village infrastructure information (Table 2). More MP residents consumed raw meat than VP residents. This is likely because the VP residents did not eat much meat, and MP residents ate more ceviche, a higher-class dish made with raw fish marinated in lemon juice.

The most meaningful response referred to consistent occupational exposure to animals, where the majority that answered ‘yes’ were from the VP communities. The transmission of pathogens from other species into human populations is an expected product of our relationship with animals and our shared environment (Karesh et al., 2012), and this finding could very well represent the zoonotic transmission of IPIs in such villages. More patients (26%) with poultry as pets were IPI positive, suggesting that they are significant sources of disease transmission among animals. Although the home is a more significant location of animal exposure, occupational exposure is also of interest. Occupational exposure is possibly due to deforestation from gas extraction, mining, logging, oil extraction, and plantation development; this poses a global health threat because of the rich microbial and wildlife biodiversity that leads to significant emerging diseases (Karesh et al., 2012).

Interventions and Prevention

Understanding village diversity regarding risk factors is essential to developing policies and strategies that address health inequity in the rural Amazon with broad, multicomponent, sustainable approaches to interventions and prevention (Brownson, Fielding, & Maylahn, 2009; Crisp, 2010; Smith, 2009). Such concerns can be dramatically reduced by targeting and preventing IPIs by ensuring water quality and availability, improving health education, improving sanitation, promoting personal hygiene practices like hand washing, promoting proper weaning and breastfeeding practices, and different combinations of interventions (Reingold & Gordon, 2012; Mackay & Chiodini, 2003). Improving water quality using pioneered research like SODIS (Solar Water Disinfection) is nearly cost-free using plastic bottles and sunlight to kill pathogens (Schlein, n.d.). When it comes to education, it is best to leave harmless practices alone and focus on understanding and changing harmful behaviors. Radio programs in the

Loreto region of Peru, using indigenous or folk terminology, are currently being used to facilitate community dialogue and disseminate health education (Dean et al., 2000; Scrimshaw, 2012). The WHO says "diarrheal diseases remain a leading cause of illness and death in the developing world," and simple hand washing with soap and water can reduce transmission by up to 35% (WHO, n.d.). Simple implementation of breastfeeding practices can dramatically reduce the 1.5 million annual infant and child deaths (Kendall-Tachett, 2012). Many methods will only be short-lived, therefore, adequate environmental sanitation and improved hygiene are really the only long-term solutions to IPI control.

Strengths and Limitations

The inability to run diagnostic tests including relatively simple stool sample tests for routine ova and parasites decreases the accuracy of diagnoses; however, this is common practice in low- and middle- income countries. A strength of this study is that no patient refused to cooperate in the research questionnaire. In the two Tapira communities there were a number of elderly people who did not understand Spanish well because they spoke the tribal language of Quechua which may be an important source of random error in that data set. Social desirability bias is also a noteworthy concern in this study. The most significant limitation to this study is the small sample size which contributed to wide confidence intervals, preventing the ability to obtain statistically significant data for inferential statistic calculations.

Conclusion

The prevalence and transmission of intestinal parasites is a significant burden on the people living in the rural Loreto region of the Peruvian Amazon. IPIs are associated with a combination of complex factors between the parasite, water, food, sanitation, zoonoses, and human health. Such factors are worsened by social determinants that increase rates of disease, exacerbate poverty, and destabilize communities. Based on the findings that have been presented, IPI prevalence, lack of health infrastructure, and limited awareness of risk factors by the studied population suggests that there is demand for preventive medical education and interventions. Although interventions are essential for healthy communities, the process of reducing morbidity and mortality due to IPIs may depend on motivating behavior change as much as on improving living conditions and new treatment development (Lowenstein, Brennan, & Volpp, 2007). The results of this research raises important questions about intestinal parasites and encourages continued research in the region in evaluating the scope and intensity of IPIs, assessment of educational and interventional measures, prevention of the main transmissive routes, as well as increasing health infrastructure and access. In communities with similar characteristics, such prevention and intervention efforts are believed to contribute to a significant reduction of IPIs and lead to better health outcomes.

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Appendix A: Vital Signs and Chief Complaints

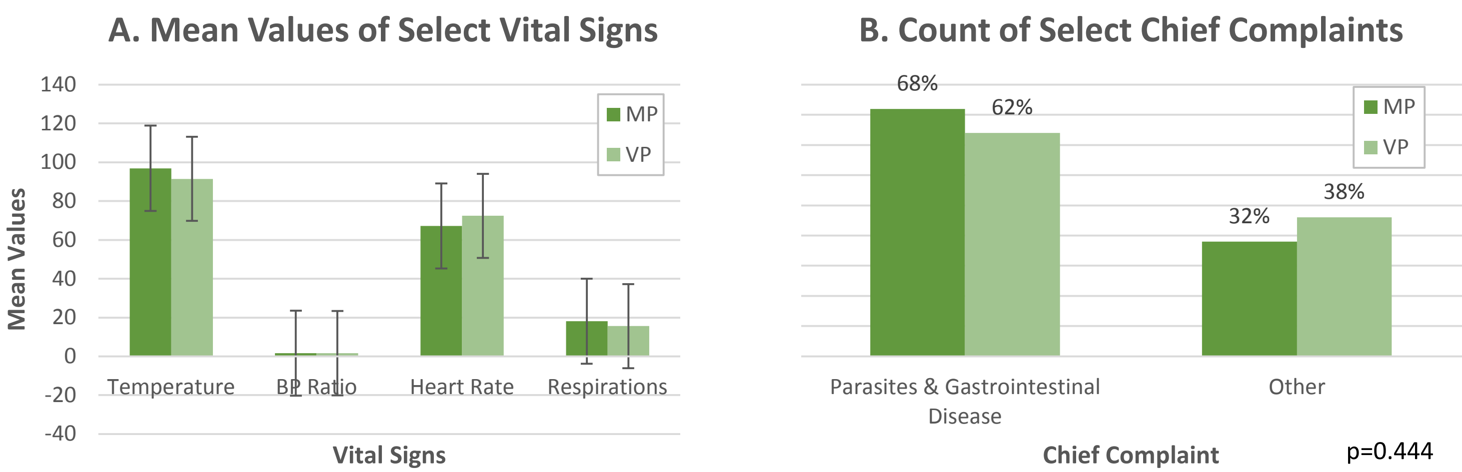

Figure 6. Mean values for select vital signs and counts for select chief complaints of residents from MP and VP communities in the Loreto region of Peru, South America.

Note. Significant Values; $p < 0.05$

Appendix B: Income Distribution in Peru

Distribution of Income or Consumption by Percentage Share: Peru	
Lowest 10%	1.6
Lowest 20%	4.4
Second 20%	9.1
Third 20%	14.1
Fourth 20%	21.3
Highest 20%	51.2
Highest 10%	35.4

Figure 7. Income shares by percentiles of the population and ranked by per capita income obtained by World Bank (2013).

Appendix C: Population without Access to Sanitation

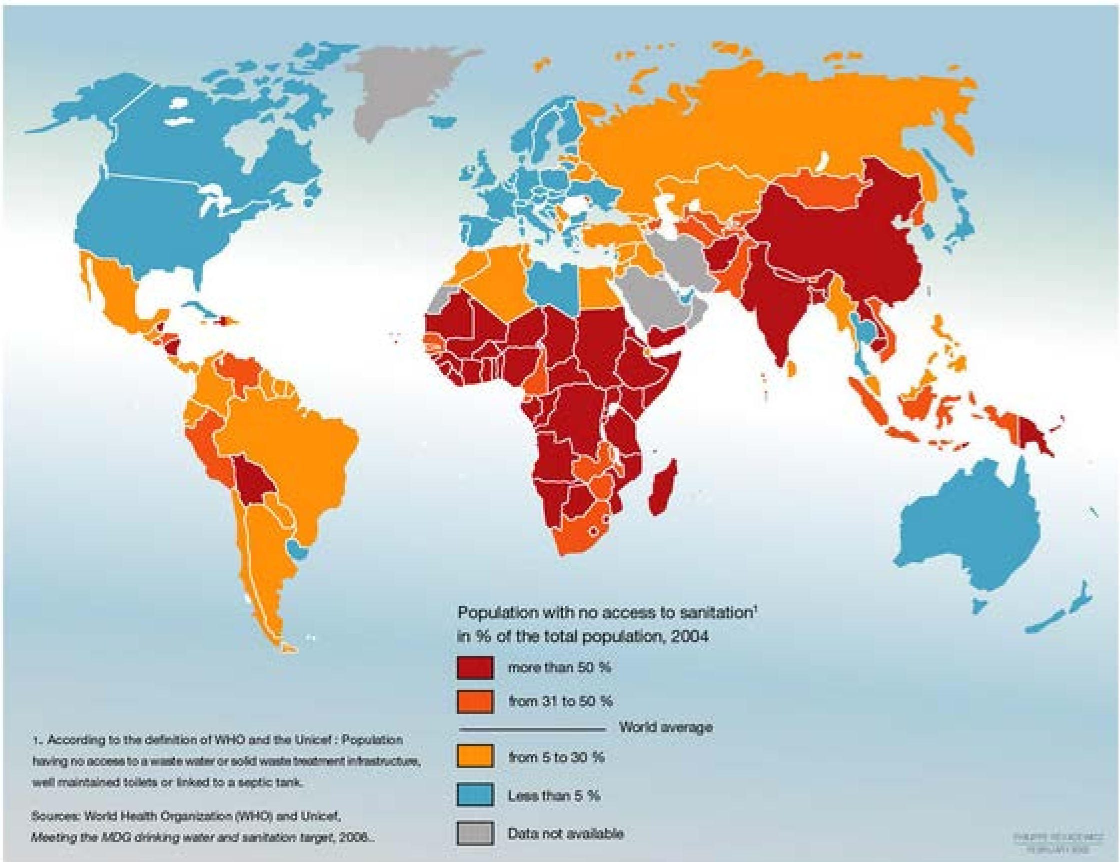

Figure 8. Percent of the total population without access to sanitation obtained from Global Poverty Project (2004).

Note. Peru's percent of the total population without access to sanitation is 'from 31 to 50%.'

Appendix D: English Survey

Public Health – Peruvian Demographic & Parasite Survey

Date: ______________ **Location:** ____

Name: ____

Demographic Information

Age: _________ **DOB:** ___/___/_______ **Gender:** ☐ M | ☐ F **Household Members:** ___________

Home Village: ____ **Children <5:** _________________

Occupation: ____ **Literacy:** ☐ Read | ☐ Write | ☐ No

Schooling: ☐ None | ☐ Other____

Medical Information

Triage Nurse Observation	Yes	No	Comments
Symptom Observations:			
Does the patient have dark circles around their eyes?	☐	☐	
Does the patient have a bluish cast around their lips?	☐	☐	
Does the patient appear malnourished or dehydrated?	☐	☐	

Temperature: _________°C **BP:** _____/_____ **Pulse:** _________bpm **Respirations:** _________

Pregnant: ☐Yes | ☐ No | ☐ N/A **Nursing:** ☐Yes | ☐ No | ☐ N/A **LMP:** _________| ☐ N/A

G____ **P**____ **A**____ **L**____ (G= Pregnancies, P= >20 Week Births, A= Pregnancies Lost, L= Live Births)

Chronic Illness: ☐ Yes ______________| ☐ No **Alcohol:** ☐ Yes | ☐ No **Smoking:** ☐ Yes | ☐ No

Chief Complaint

☐ Fever ______________ ☐ Cough ____________ ☐ Runny Nose ___________ ☐ Sore Throat ___________

☐ Headache __________ ☐ Pain ______________ ☐ Vomiting ____________ ☐ Diarrhea ____________

☐ GU _______________ ☐ Parasites __________ ☐ Skin Problems _________ ☐ Dental ______________

☐ Other ____

How Long Has CC Bothered You: ____

Medications: ☐ Yes ________________________| ☐No **Allergies:** ☐ Yes _______________________| ☐No

Doctor Information

Physical Exam: ____

____

____

Assessment:

☐ Viral URTI / LRTI ☐ AGE / Diarrhea ☐ Migraine / Tension HA ☐ UTI ☐ Hypertension

☐ Pneumonia ☐ Dysentery ☐ Conjunctivitis ☐ Pyelonephritis ☐ Diabetes

☐ Influenza ☐ Reflux ☐ Acute Otitis Media ☐ Yeast / BV Infection ☐ Goiter / Thyroid

☐ Strep Throat ☐ Parasites ☐ Allergic Rhinitis ☐ STI ☐ Muscle Strain

☐ Asthma / COPD ☐ Malnutrition ☐ Poor Dentition ☐ Other __________________________

Appendix D Continued

Public Health – Peruvian Demographic & Parasite Survey

Doctor Information Continued

Plan / Treatment:

☐ Vitamins____________	☐ Keflex____________	☐ Antifungal Cream________	☐ Antiparasitics__________
☐ Ibuprofen___________	☐ Doxycycline_______	☐ Diaper Cream___________	☐ Antacid/Pepsid_________
☐ Tylenol_____________	☐ Cipro____________	☐ Diflucan_______________	☐ BBG w Saline__________
☐ Loratidine___________	☐ Augmentin________	☐ Brush Teeth 2X Daily_____	☐ Other________________

____

Treatment Length: ____________________ **Preventative Measures:** ☐ Yes ______________________| ☐ No

Parasite Knowledge of Risk Factors

Questions	Yes	No	Comments
Water Questions:			
Do you often bathe or swim in creeks or rivers?	☐	☐	
Is your drinking water from the river?	☐	☐	
Do you ever drink river water without boiling or filtering it first?	☐	☐	
Food Questions:			
Do you eat unpeeled fruits and vegetables?	☐	☐	
Do you eat fish or meat that is undercooked?	☐	☐	
Animal Questions:			
Do animals live in your house?	☐	☐	Which Ones?
Do you regularly work with or around animals?	☐	☐	Which Ones?
Sanitation Question:			
Do you wash your hands before eating?	☐	☐	
Do you regularly walk barefoot?	☐	☐	
Signs & Symptom Questions:			
Is your stomach swollen even when you haven't eaten?	☐	☐	
Do you have stomach cramps?	☐	☐	
Does it hurt or do you strain when you poop?	☐	☐	
Do you often have diarrhea (3 loose stools daily)?	☐	☐	
Do you often have nausea and/or vomiting?	☐	☐	
Have you passed a worm in your stool?	☐	☐	
Is your urine or stool sometimes red (bloody)?	☐	☐	
Are you regularly tired, even after sleeping?	☐	☐	

Appendix E: Spanish Survey Translation

Salud Pública – Encuesta Peruana Demografica y Parasitológica

Fecha: ______________ **Ubicación:** ____

Nombre: ____

Información Demográfica

Edad: _____ **Fecha de nacimiento:** ____/____/_______ **Sexo:** ☐ M | ☐ F **Número de personas en casa:**_________

Pueblo: ____ **Niños <5:** _________________________

Ocupación: ____ **Alfobetismo:** ☐ Leer | ☐ Escribir | ☐ No

Escuela: ☐ Nada | ☐ Otra____

Información Medica

Observación de Enfermera	Sí	No	Comentarios
Observación de Síntomas:			
¿Tiene el/la paciente círculos oscuros rodeando los ojos?	☐	☐	
¿Tiene el/la paciente un color azul alrededor de los labios?	☐	☐	
¿Parece el/la paciente a estar desnutrido o deshidratado?	☐	☐	

Temperatura: _______°C **Presión sanguínea:** ______/______ **Pulso:** __________ **Respiraciones:** __________

Embarazada: ☐ Sí | ☐ No | ☐ N/A **Amamantando:** ☐ Sí | ☐ No | ☐ N/A **Fecha de ultima menstracion:**____| ☐ N/A

E____ **P**____ **A**____ **L**____ (E= Embarazos, P= >20 Semanas, A= Embarazos Perdidos, L= Embarazos Vivos)

Enfermedes Crónicas: ☐ Sí ___________| ☐ No Bebe **Alcohol:** ☐ Sí | ☐ No **Fuma:** ☐ Sí | ☐ No

Enfermedad Primaria

☐ Fiebre _____________ ☐ Toz _______________ ☐ Constipación Nasal _______ ☐ Garganta Adolorida_______

☐ Dolor de cabeza ______ ☐ Dolor _____________ ☐ Vómito _______________ ☐ Diarrea _______________

☐ GU _________________ ☐ Parásito ___________ ☐ Problemas de Piel _______ ☐ Dental ________________

☐ Otro____

Por cuanto tiempo lo ha molestado: ____

Medicamentos: ☐ Sí _______________________| ☐ No **Alergias:** ☐ Sí _______________________| ☐ No

Información de Médico

Examen Físico: ____

____

____

Evaluación:

☐ Virus Respiratorio ☐ Gastritis/Diarrea ☐ Dolor de Cabeza ☐ Infeccion Urinaria ☐ Presión Elevada

☐ Neumonía ☐ Disentería ☐ Conjunctivitis ☐ Pielonefritis ☐ Diabetes

☐ Influenza ☐ Acidez ☐ Infección de oído ☐ Infección Vaginal ☐ Bocio / Tiroides

☐ Garganta de Strep ☐ Parásito ☐ Alergias ☐ ETD ☐ Torcedura

☐ Asma / EPOC ☐ Desnutrición ☐ Caries ☐ Otra ______________________________

Appendix E Continued

Salud Pública – Encuesta Peruana Demografica y Parasitológica

Información de Médico Continuado

Plan / Tratamiento:

☐ Vitaminas____________	☐ Keflex_____________	☐ Crema Antihongos________	☐ Antiparasiticos__________
☐ Ibuprofeno__________	☐ Doxycycline_________	☐ Crema para Pañal________	☐ Antacido/Pepsid_________
☐ Acetaminofen_________	☐ Cipro_____________	☐ Diflucan________________	☐ BBG con salino __________
☐ Loratidine____________	☐ Augmentin_________	☐ Cepillar dientes 2X diario__	☐ Otra__________________

____

Duración de Tratamiento: __________________ **Medidas Prevenidas:** ☐ Sí ________________________| ☐ No

Parásito Conocimiento de Factores de Riesgo

Preguntas	Sí	No	Comentarios
Preguntas de Agua:			
¿Usted se baña o nada en el río frequentemente?	☐	☐	
¿El agua que usted bebe, viene del río?	☐	☐	
¿Usted bebe el agua del río sin herviéndolo o filtrándolo primero?	☐	☐	
Preguntas de Comida:			
¿Usted come fruta o vegetal no pelado?	☐	☐	
¿Usted come pescado o carne que no esta suficientemente cocido?	☐	☐	
Preguntas de Animales:			
¿Viven animales en su casa?	☐	☐	¿Cuales?
¿Usted trabaja con o alrededor de animales con frequencia?	☐	☐	¿Cuales?
Preguntas de Saneamiento:			
¿Se lava los manos antes de comer?	☐	☐	
¿Usted camina descalzo frequentemente?	☐	☐	
Preguntas de Indicios y Síntomas:			
¿Está su barriga hinchado aunque no ha comido?	☐	☐	
¿Usted tiene calambres del estómago?	☐	☐	
¿Le duele cuando defeca? ¿Ole es difícil?	☐	☐	
¿Usted tiene diarrea con frequencia (tres de líquido a diaria)?	☐	☐	
¿Usted tiene nausea o vómito frequentemente?	☐	☐	
¿Usted ha tenido un lombrice en su heces?	☐	☐	
¿Está rojo su orina o heces? ¿O con sangre?	☐	☐	
¿A menudo tiene sueño, aunque ha dormido?	☐	☐	

Appendix F: IRB Permission

WRIGHT STATE UNIVERSITY

Office of Research and Sponsored Programs
201J University Hall
3640 Col. Glenn Hwy.
Dayton, OH 45435-0001
(937) 775-2425
(937) 775-3781 (FAX)
e-mail: rsp@wright.edu

DATE: April 18, 2013

TO: Jonathan M. Stofer, PI, Graduate Student
Public Health
Cristina Redko, Ph.D., Faculty Advisor

FROM: Bette Sydelko, MS.L.S., M.Ed. BS
Facilitator, Expedited Review Advisory Committee

SUBJECT: SC# 5112
'A Primary Care and Parasite Risk Factor Assessment of Short-Term Medical Clinics in the Rural Peruvian Amazon'

This memo is to verify the receipt and acceptance of your response to the conditions placed on the above referenced human subjects protocol/amendment.

These conditions were lifted on: 04/18/2013

This study/amendment now has full approval and you are free to begin the research project. If this is a VA proposal, you must still receive a letter of approval from the Research and Development Committee prior to beginning the research project. If this is a MVH proposal, you must still receive a letter of approval from the Human Investigation and Research Committee (HIRC) prior to beginning the research project. This implies the following:

1. That this approval is for one year from the approval date shown on the Action Form and if it extends beyond this period a request for an extension is required. (Also see expiration date on the Action Form)

2. That a progress report must be submitted before an extension of the approved one-year period can be granted.

3. That any change in the protocol must be approved by the IRB; otherwise approval is terminated.

If you have any questions concerning the condition(s), please contact Jodi Blacklidge at 775-3974.

Thank you!
Enclosure

Appendix F Continued

RESEARCH INVOLVING HUMAN SUBJECTS

SC# 5112

ACTION OF THE WRIGHT STATE
UNIVERSITY
EXPEDITED REVIEW
Assurance Number: FWA00002427

Title: *'A Primary Care and Parasite Risk Factor Assessment of Short-Term Medical Clinics in the Rural Peruvian Amazon'*

Principal Investigator: Jonathan M. Stofer, PI, Graduate Student
Cristina Redko, Ph.D., Faculty Advisor

Department: Public Health

Expedited Category: 7

The Institutional Review Board has approved the use of human subjects on this proposed project with conditions previously noted. The conditions have now been removed.

REMINDER: FDA regulations require prompt reporting to the IRB of any changes in research activity, changes in approved research during the approval period may not be initiated without IRB review (submission of an amendment), and prompt reporting of any unanticipated problems (adverse events).

Bette S. Sydelko
Signed Facilitator, WSU-ERAC

Expedited Review Date: March 22, 2013

IRB Meeting Date: May 20, 2013

This approval is effective only through: March 22, 2014
To continue the activities approved under this protocol you should receive the appropriate form(s) from Research and Sponsored Programs (RSP) two to three months prior to the required due date. If you do not receive this notification, please contact RSP at 775-2425.

Appendix G: Global Partners Permission

GLOBAL PARTNERS

March 11, 2013

To Whom It May Concern:

Global Partners is the missionary sending agency for The Wesleyan Church Corp. This letter serves to grant permission from Global Partners for Jonathan Stofer to conduct a parasite study as a part of an upcoming short-term trip.

Mr. Stofer will be traveling with a team composed of several nurse practitioners, nurses, public health students, and undergraduate students from May 24th through June 8th. The team is going to host clinics in four villages within the Peruvian Amazon as they have done in the past, and in the triage station of each clinic Mr. Stofer is preparing to implement a survey. He hopes to use this information in order to better describe and assess parasite related risk factors on the people that attend the clinics. It is his purpose to highlight concerns where possible interventions could be made in the region and also to improve efforts in the breadth of volunteer care efforts in this and similar clinical environments.

Global Partners is aware of the plans to conduct this survey and has given Mr. Stofer permission to do so. If you have any questions regarding this matter, please feel free to contact me by phone at 317.774.7982, or by e-mail at scottd@wesleyan.org.

Sincerely,

Rev. David Scott
Teams Coordinator
Global Partners

13300 Olio Road
Fishers, IN 46037

Office: 317.774.7950
Fax: 317.774.7958
globalpartners@wesleyan.org
www.globalpartnersonline.org

Appendix H: Frieden's Hierarchy of Needs

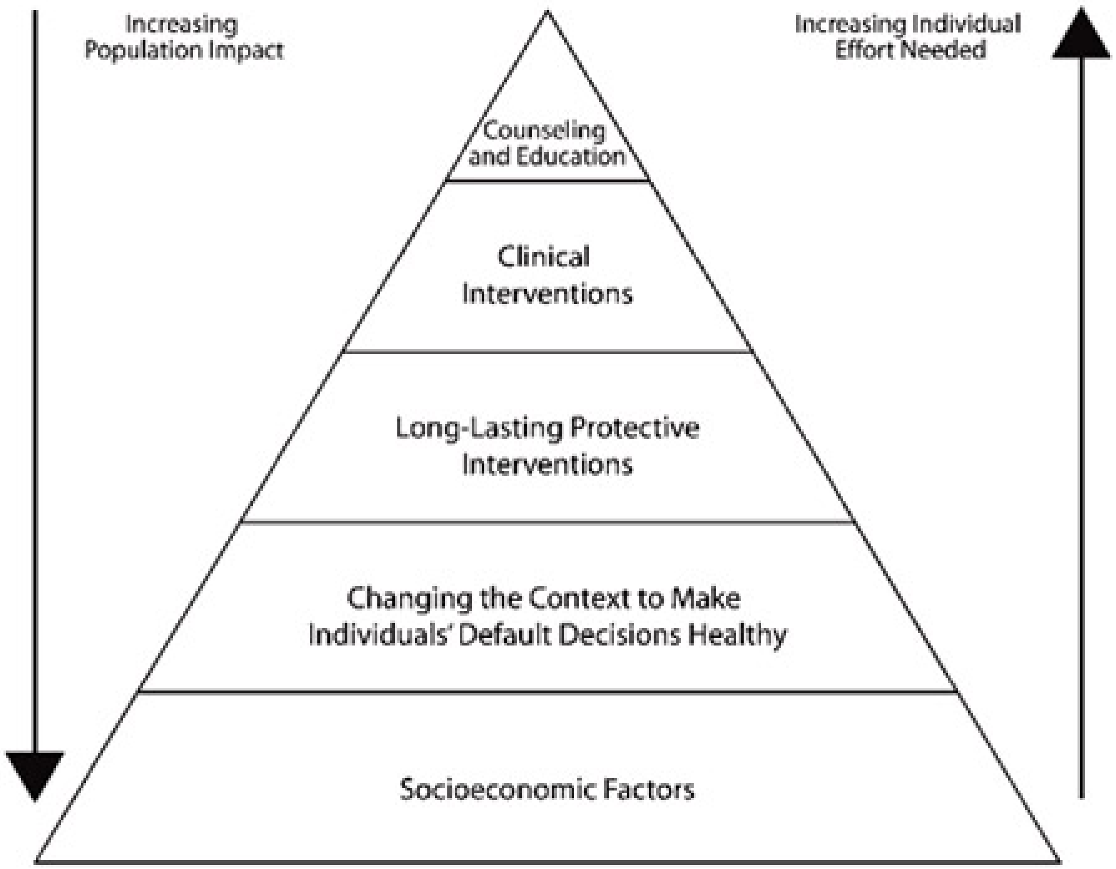

Figure 9. Frieden's hierarchy of needs obtained from Frieden (2010).

Appendix I: Common IPIs and Their Symptoms

Table 7

Presentation of Common IPIs in Human Hosts

		Abdominal Pain	Asymptomatic$^{\theta}$	Blood in Stool	Constipation	Cough$^{\varphi}$	Dizziness	Diarrhea	Dysentery*	Fatigue	Fever	Flatulence	Malabsorption	Mucus in Stool	Myalgias	Nausea	Rash / Lesions	Rectal Prolapse	Vomiting	Weight Loss
Protozoa	***Balantidium coli***	X	X					X	X				X			X			X	X
	Cryptosporidium parvum	X	X					X		X	X			X		X			X	X
	Cyclospora cayetanensis	X	X					X		X		X			X	X				X
	Entamoeba histolytica	X	X	X	X			X	X		X			X						
	Giardia lamblia	X	X					X		X		X	X	X		X			X	X
	Cystoisospora belli	X						X			X					X			X	X
Fungi	***Enterocytozoon bieneusi***	X	X					X					X							X
Helminthes	***Macracanthorhynchus hirudinaceous***	X		X	X			X			X					X			X	X
	Ascaris lumbricoides	X	X		X	X					X		X					X		
	Necator americanus	X	X				X			X	X		X			X	X			X
	Hymenolepis nana	X	X					X		X					X					X
	Schistosoma mansoni	X	X		X	X		X			X						X			
	Strongyloides stercoralis	X	X		X	X		X		X					X	X	X		X	X
	Trichuris trichiura	X	X	X				X						X				X		

Note. * Dysentery is severe diarrhea with mucus and/or blood in the feces, abdominal pain, fever, and rectal tenesmus.
$^{\theta}$ Infected individuals can be carriers without symptoms $^{\varphi}$
With or without blood

Data for Balantidiasis was collected from Swartzwelder (1950), Esteban, et al. (1998), Ferry, et al. (2004), for Enterocytozoon *bieneusi* from Matos, Lobo, & Xiao (2012), for Cryptosporidium and Giardia from Huang & White (2006), and all other information from CDC (2013), Heymann (2008), and Papadakis, McPhee, & Rabow (2013).

Appendix J: List of Competencies Used in CE

Tier 1 Core Public Health Competencies

Domain #1: Analytic/Assessment
Identify the health status of populations and their related determinants of health and illness (e.g., factors contributing to health promotion and disease prevention, the quality, availability and use of health services)
Describe the characteristics of a population-based health problem (e.g., equity, social determinants, environment)
Use variables that measure public health conditions
Use methods and instruments for collecting valid and reliable quantitative and qualitative data
Identify sources of public health data and information
Recognize the integrity and comparability of data
Identify gaps in data sources
Adhere to ethical principles in the collection, maintenance, use, and dissemination of data and information
Collect quantitative and qualitative community data (e.g., risks and benefits to the community, health and resource needs)
Use information technology to collect, store, and retrieve data
Domain #2: Policy Development and Program Planning
Gather information that will inform policy decisions (e.g., health, fiscal, administrative, legal, ethical, social, political)
Participate in program planning processes
Domain #3: Communication
Identify the health literacy of populations served
Communicate in writing and orally, in person, and through electronic means, with linguistic and cultural proficiency
Solicit community-based input from individuals and organizations
Apply communication and group dynamic strategies (e.g., principled negotiation, conflict resolution, active listening, risk communication) in interactions with individuals and groups
Domain #4: Cultural Competency
Recognize the role of cultural, social, and behavioral factors in the accessibility, availability, acceptability and delivery of public health services
Respond to diverse needs that are the result of cultural differences
Domain #5: Community Dimensions of Practice
Collaborate with community partners to promote the health of the population
Maintain partnerships with key stakeholders
Describe the role of governmental and non-governmental organizations in the delivery of community health services
Identify community assets and resources
Domain #6:Public Health Sciences
Describe the scientific evidence related to a public health issue, concern, or, intervention
Retrieve scientific evidence from a variety of text and electronic sources
Discuss the limitations of research findings (e.g., limitations of data sources, importance of observations and interrelationships)
Describe the laws, regulations, policies and procedures for the ethical conduct of research (e.g., patient confidentiality, human subject processes)
Domain #7: Financial Planning and Management
Describe the local, state, and federal public health and health care systems
Domain #8: Leadership and Systems Thinking
Incorporate ethical standards of practice as the basis of all interactions with organizations, communities, and individuals
Participate with stakeholders in identifying key public health values and a shared public health vision as guiding principles for community action
Use individual, team and organizational learning opportunities for personal and professional development
Participate in mentoring and peer review or coaching opportunities

Concentration Competencies

Global Health:
Identify strategies that strengthen community capabilities for overcoming barriers to health and well-being
Exhibit interpersonal skills that demonstrate willingness to collaborate, trust building abilities, and respect for other perspectives
Identify and respond with integrity and professionalism to ethical issues in diverse economic, political, and cultural contexts
Conduct evaluation and research related to global health