UNDERSTANDING RISK DETERMINANTS OF CHAGAS DISEASE IN PERI-URBAN PERU

by

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ABSTRACT

Infestation of homes with *Triatoma infestans*, an important vector of Chagas disease in southern Peru, is common in the peri-urban shantytown communities of Arequipa, Peru. Prevalence rates of Chagas disease are not well-known because of the disease’s insidious nature. This unknown element of a potentially fatal disease necessitates a proactive and preventative approach. Household vector sprayings have been conducted to eliminate *T. infestans* infestation in communities within and surrounding Arequipa. At the time of the spraying, household surveys were conducted in Nueva Alborada, one of these communities, to determine the distribution of certain animal and peridomestic and domestic housing types. Spatial and statistical analyses of this data indicate that guinea pigs, dogs, sheep, chickens, and cracks on household walls are associated with *T. infestans* infestation. The distance of a home from another containing 20 or more bugs is also very significant in explaining infestation. This finding suggests that highly infested homes contribute to vector dispersal. Semi-structured interviews with founders of Nueva Alborada provide insight about the historical elements that have influenced the development of the community and establishment of *T. infestans*. Understanding how the spatial, animal, and household predictors relate to household vector infestation in Nueva Alborada, and how the city’s history shaped the current situation can potentially provide insight for other Peruvian peri-urban communities with *T. infestans* in order to improve Chagas disease prevention efforts.
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# TABLE OF CONTENTS

ABSTRACT ........................................................................................................................................... ii
ACKNOWLEDGMENTS ......................................................................................................................... iii
TABLE OF CONTENTS ........................................................................................................................ iv
FIGURES AND TABLES ........................................................................................................................ v
PREFACE ............................................................................................................................................... 1

CHAPTER 1: LAND TENURE AND RURAL-TO-URBAN MIGRATION IN PERU ........................................... 2

CHAPTER 2: QUANTITATIVE ANALYSIS OF *T. INFESTANS* CHAGAS DISEASE VECTOR IN NUEVA ALBORADA, PERU

  Introduction ........................................................................................................................................ 12
  Methods and Materials ....................................................................................................................... 16
  Results ............................................................................................................................................. 20
  Discussion ....................................................................................................................................... 23

CONCLUSION ...................................................................................................................................... 28

FIGURES ........................................................................................................................................... 29

TABLES ............................................................................................................................................. 33

APPENDIX A: REPORT FOR NUEVA ALBORADA HEALTH CLINIC ...................................................... 37

APPENDIX B: SEMI-STRUCTURED INTERVIEW QUESTIONS (SPANISH) ............................................. 41

APPENDIX C: SEMI-STRUCTURED INTERVIEW QUESTIONS (ENGLISH) ........................................... 42

APPENDIX D: LIST OF INTERVIEWEES ............................................................................................. 43

REFERENCES ....................................................................................................................................... 45
FIGURES

Figure 1: Map of the region................................................................. 29
Figure 2: Aerial photograph of the study site ............................................. 30
Figure 3: Nueva Alborada map indicating household T. infestans presence......... 31
Figure 4: Nueva Alborada map indicating households with 20 or more T. infestans..... 32

TABLES

Table 1: Prominent animals associated with T. infestans................................... 33
Table 2: Logistic univariate regression .......................................................... 34
Table 3: Linear univariate regression ............................................................. 34
Table 4: Logistic multiple regression ............................................................ 35
Table 5: Linear multiple regression ............................................................... 36
PREFACE

My thesis is divided into two distinct chapters to reflect the qualitative and quantitative factors affecting the presence of ‘kissing bugs,’ the Chagas disease vector, in shantytown communities of Arequipa, Peru. To contextualize the quantitative analysis, in the first chapter I explain the migratory, political, and historical factors surrounding the development of these shantytown communities on the periphery of Arequipa. I describe some land reform and tenure practices which occurred in Peru because it helps show why and how the shantytowns initially emerged. The process of shantytown development was elucidated through semi-structured interviews I conducted with members of these communities. The poverty conditions in the shantytowns of Arequipa are associated with the presence of the Chagas disease vector, a main element of Chagas disease transmission further described in the second chapter. The second chapter is a quantitative analysis of household survey data in which I focus on risk factors influencing the presence of ‘kissing bugs’ in one particular community, Nueva Alborada. This chapter is structured for publication in a scientific journal.
CHAPTER 1: LAND TENURE AND RURAL-TO-URBAN MIGRATION IN PERU

Introduction

Shantytowns are prevalent in many parts of the world and they expose underlying problems of poverty and unequal opportunities in society. The formation of the shantytown communities, or pueblos jóvenes, in Arequipa, Peru has a rich history based in political movements, migration patterns, and socio-economic factors. The impoverished conditions of shantytowns make them vulnerable to certain diseases. Chagas disease is known to be associated with poverty and is designated a “neglected tropical disease” by the World Health Organization. This chapter analyzes the political and social history of Peru to help explain rural-to-urban migration patterns that have led to the formation of pueblos jóvenes; this analysis will contextualize the city of Arequipa with the ultimate goal of understanding how political and social factors, formation of pueblos jóvenes, and Chagas disease are connected.

History

Studying political, geographical, and social events in Peru’s history is important in understanding how urban shantytown communities developed. Prior to the 1940s little rural-to-urban migration occurred in Peru, but an earthquake in 1940 triggered the first main influx of urban squatters (Strassmann, 1984). However, urban land invasions resulting in peri-urban shantytowns were substantial after World War II, especially in the 1950s and 60s (Bromley, 2003). Bureaucracy and slow governmental response passively allowed these illegal invasions of public land to occur. Manuel Prado, President of Peru from 1956-62, did little to address the problems of struggling rural peasants or urban poor during his administration. He established the Commission of Agrarian Reform and Housing, but this agency did not drastically address the concerns either; some pilot programs emerged, but
widespread reform was nonexistent (Bromley, 2003). Fernando Belaúnde, President from 1963-1968, also offered minimal support in creating an effective system to accommodate the influx of rural migrants in urban areas. Lima experienced extensive development of *barriados*, another term for shantytowns, during this period; by 1970, one-third of Lima’s population lived in these shantytown communities (Klarén, 2000).

The most dramatic changes regarding governmental attention to the *barriados* occurred during the regime of General Juan Velasco (1968-1975). During his administration, radical agrarian reform was instituted, and efforts to accommodate burgeoning shantytowns were made. Even the name of shantytowns changed from *barriado* to the euphemistic phrase *pueblo joven*, or “young town.” Velasco created a “National Office for Young Towns” (ONDEPJOV), an agency dedicated to supporting the shantytowns. During the reform, transnational corporations were expropriated, plantation ownership shifted from system of large estates, or *hacienda* s, to a cooperative system, and mines came under state control. The agrarian reform disbanded haciendas to redistribute income; however, coastal farms benefitted much more from the reforms than peasants from the highlands. The coastal farms, often sugar plantations, received more from the reforms because their land value was approximately six times higher than that of the highland peasant land, and their operations were modernized and profitable (Klarén, 2000). Only one-fourth of the rural population acquired land access from this reform, which indicates its overall ineffectiveness (Klarén, 2000).

In 1971, an agency called *Sinamos*, part of the “National System of Support for Social Mobilization,” was established to address governmental policy involving shantytowns (Bromley, 2003). The acronym also doubled as a reference to the phrase *sin amos*, which
means “without masters.” *Sinamos* had an important role of helping establish government policies regarding shantytowns and promoted policies of common property ownership and group decision making. However, this was difficult to implement because of the contradictory nature of the federal government; on one hand, the government was supporting bottom-up grassroots initiatives in shantytowns but at the same time the Velasco period was a authoritarian military regime, which had started with a coup d’etat. These disparate approaches contributed to the unsustainability of the *Sinamos* program. In addition to the opposing ideologies, the *Sinamos* program was inadequately funded, which contributed to its eventual demise. The program was completely dissolved by Velasco’s successor, General Morales Bermúdez, in 1977 (Bromley, 2003).

During the 1980s several factors contributed to additional rural-to-urban migration movements. The El Niño effect occurred in 1982 and 1983 causing massive flooding and damage to crops. As a result, the country’s GPD dropped 12.6% during these two years and rural residents migrated to urban centers in search of work (Chambers, 2005). The *Sendero Luminoso* (Shining Path) terrorist movement also provided an impetus for rural residents to migrate in the 1980s. This Maoist organization found Velasco’s regime to be “bureaucratic capitalism” and hoped to initiate a world revolution (Klarén, 2000). However, their tactics were often violent and included actions such as the burning of ballot boxes in a small Andean village, hangings of dead dogs from lamp posts, assassinations of public officials and public leaders, and bombings (Klarén, 2000). A state of emergency was declared allowing military control of certain areas. The combination of *Sendero Luminoso* violence coupled with the repressive counterinsurgency military presence resulted in over 30,000 casualties from 1980-1997 (Chambers, 2005).
Some major reforms in land titling occurred in the 1980s and 90s, which had a dramatic effect on the number of squatters with property rights. Inefficiencies of the government resulted in lengthy processes of obtaining a land title, so the dramatic reform which occurred in 1996 was needed. The precursor to the 1996 reforms was a law in 1988 which established a registry entitled “Real Estate Registry of Informal Settlements and Popular Urbanizations” to formally recognize parcels and associated property rights.

The 1988 registry was further strengthened in 1996 by the creation of Comisión de Formalización de la Propiedad Informal, COFOPRI, (“Committee for the Formalization of Private Property”), an agency in charge of reforming the transfer of property rights and encouraging land and building investments (Cantuarias and Delgado, 2004). COFOPRI helped reduce costs for land title acquisition and was largely successful: Prior to these reforms in 1996, more than one-fourth of urban residents in Peru did not have legal rights to property (World Bank, 1997). By December 2001, 80% of eligible urban squatter residents without a land title became property owners (Field, 2005). The new process of land entitlement was much more efficient, cheap, and effective than the previous system; in addition, locals were trained and all lots were digitally mapped (Field, 2007). Some of resulting associated benefits of the acquisition of land title included access to property rights, credit through use of property as collateral, and higher likelihood of infrastructure and utilities access. Field’s analysis of property analysis in Peruvian shantytowns indicated a relationship between property rights acquisition and investment: “Land titling is associated with a 68% increase in the rate of housing renovation within only four years of receiving a title” (2005, p. 280). This connection between property rights and land investment incentives is supported by economic theory (Field, 2005).
Peruvian economist Hernando de Soto is a strong advocate of the conferral of property rights and helped promote it through founding the *Instituto Libertad y Democracia* “ILD” (Institute for Liberty and Democracy) in May 1980 (Becker, 1996). The ILD researched the status of squatters in the 1980s and helped show how tedious and almost impossible land title acquisition could be for squatters. Hernando de Soto’s connections with Peruvian elites may have helped give more clout to the importance of the ILD research (Becker, 1996). Although property rights acquisition may be linked to benefits such as land investment, privatization of property also is associated with some downsides, but they are beyond the scope of this study.

**Urban Migration Models**

Many researchers have analyzed migration and settlement patterns in relation to shantytowns. John Turner published the foundational papers about intra-urban migration patterns in Lima, Peru during the 1960s. Turner’s model separates urban migrants into three categories: bridgeheaders, consolidators, and statusseekers. Bridgeheaders are characterized by single individuals whose main priority in determining where to live in the city is distance to a job. Consolidators typically have a family and job and focus their energies on establishing land tenure and finding a place near the edge of the city. The final group, statusseekers, have a home on the edge of the city and want to improve their home. Migrants to Arequipa also fill these roles. However, since the historic center of Arequipa has limited capacity for new incomers, migrants often settle in the city periphery, establishing themselves in the consolidator role (Schuurman, 1986).

Another model shows the way in which shantytowns develop. While critics may perceive shantytowns negatively with visions of high crime, sprawling growth, and no order,
the formation of *pueblos jóvenes* is often an organized event with subsequent development typically following a pattern of progression. Often a shantytown is established when a group of families “invade” an area of public land together. The group strategically selects a time and location; often the invasion occurs during a holiday or a time when police are unlikely to intervene and the squatters typically choose low-quality land to reduce the likelihood of expulsion. Squatters are eligible to acquire legal tenure if they remain on the site for 24 hours without being evicted (Chambers, 2005). The pattern of housing development is also somewhat predictable with each step adding more structural permanence to the residency. In the initial stage invaders put up posts and reed mats for the walls (Chambers, 2005 and Strassmann, 1984). A rustic wall of loose stones is often used to delineate the lot (Chanfreau, 1988). During the following stage brick or adobe walls are constructed around the lot with *noble*, or cemented material, finally added to create bedroom walls. The final stage is the most expensive and involves hiring someone to add steel reinforcement and a concrete roof. During the final step concrete floors and windows are often added (Chambers, 2005).

The rate and type at which house construction improvement occurs is variable. According to a research study of Lima shantytowns, income affects the type of material used in housing construction whereas access to water and sewage infrastructure affects the rate at which housing improvements occur (Strassmann, 1984). The theory is that the rate increases because families with this infrastructure access make improvements in their home as a rational investment. Even so, many homes never make it or take 10-20 years to reach the final stage of having a concrete roof and floor (Chambers, 2005). These settlement patterns in Peru can be better understood by focusing on the example of the city of Arequipa.
Case study: Arequipa, Peru

The city of Arequipa has approximately one million inhabitants and its shantytowns follow the standard pattern of development. Research studies about Arequipa’s *pueblos jóvenes*, in addition to interviews I conducted with residents, reveal some of the mechanisms involved in shantytown development.

The landscape of the area around Arequipa is a significant factor that influences where urban growth is physically able to occur. Some of the natural boundaries are the Chili River, which divides the city, and a mountain chain. The mountain chain prevents urban growth from spreading to the east. Drought in the 1950s in southern Peru caused families to move to Arequipa, the main urban center in southern Peru, for work opportunities. More than 13,000 people were residents of Arequipa’s shantytowns by 1956 (Schuurman, 1986). Additional natural disasters such as the earthquakes in 1958 and 1960 provoked further rural-to-urban migration to Arequipa. The main settlers of the first *pueblos jóvenes* of Arequipa were principally Arequipan natives displaced by the earthquakes (Chanfreau, 1988 and Niño de Guzman, P., pers. comm.). Arequipa’s large size relative to other cities in the region increases its “pull” factor in encouraging migration for jobs; Leyton Muñoz noted how Arequipa was 25 times larger than the next largest city in the region, which had a population of 31,000 (1993). In the 1970s the majority of residents in *pueblos jóvenes* were no longer native Arequipans, but people from Puno, a region in the Peruvian Andes (Chanfreau, 1988). Migrants from Andean rural areas influenced characteristics of shantytown development with houses retaining traits of a rural lifestyle. Houses in *pueblos jóvenes* often have patios, terraces, and peridomestic areas for animals such as guinea pigs, cats, dogs, pigs, and sheep (Fraser, 2008).
Informal interviews that I conducted with pueblos jóvenes residents highlight some of the trends of land tenure establishment and housing development in relation to the appearance of ‘kissing bugs.’ I conducted 31 interviews in Spanish with residents of eight Arequipan pueblos jóvenes (Nueva Alborada, Texas 2000, Villa Los Pinos, Santa María I, Santa María II, Buena Vista I, Buena Vista II, and Buena Vista III) in order to understand how and when these communities formed, and what the residents knew about ‘kissing bugs.’ The semi-structured interview questions are listed in Appendices B and C while names of interviewees, their community of residence, and interview date are listed in Appendix D. My goal was to interview community founders since they would have witnessed the progression of community settlement. In order to find these individuals, I contacted the volunteer health promoters since they were familiar with where people lived within their district. In addition to the interviews with community founders, I also interviewed some health promoters.

The informal interviews with residents of pueblos jóvenes uncover historical information about pueblo joven formation that is not as well documented, especially concerning the unofficial versus official founding dates of the communities. Although the municipality establishes an official foundation date of these communities, they often are settled by squatters years or decades before the official date. For example, according to municipality records, the pueblo joven Nueva Alborada was officially recognized on August 20, 1992, but interviews with community members indicate that residents arrived in the area much earlier. In 1982 Mr. Julio Málaga was the first founder of the community. Don Porfirio Niño de Guzman started living in Nueva Alborada in 1983 and in 1984 the Nueva Alborada association was formed (Niño de Guzman, P., pers. comm.). The squatters began to organize even though they did not have official land plots. When they arrived to the
hillside, the land was empty and there was no running water or sewage system. In general the people settling the area did not come with livestock or animals at that time. Nueva Alborada used to belong to La UPA, a central organization of pueblos jóvenes but then disassociated when the organization politicized. Around 1988 the banco de materiales (material bank) gave assistance to almost everyone living in Nueva Alborada. Similar patterns of shantytown establishment are found in other pueblos jóvenes of Arequipa.

**Chagas disease**

Chagas disease is known to be associated with poverty conditions, so it is not surprising that it has emerged in the pueblos jóvenes of Arequipa, Peru. The loosely placed rocks initially constituting the rudimentary phase of house establishment create ideal places for the Triatoma infestans insect vector to hide during the day and to lay their eggs. The gradual process of housing improvements such as sealing the walls and floors creates a period in which the T. infestans can become established in the house. Poor housing conditions are known to be associated with higher numbers of triatomines (Cetron, 1995). Residents of the pueblos jóvenes that I interviewed often attributed the presence of ‘kissing bugs’ to animals and unclean homes. Rural migrants that bring their domestic animals and livestock to the pueblos jóvenes also unknowingly provide additional blood meal sources for the T. infestans. The proximity of the animals to the bedrooms may facilitate T. infestans feeding on humans. Chapter 2 focuses more specifically on domestic animals and housing types in and how they correlate with T. infestans in Nueva Alborada.

**Conclusion**

Shantytown communities exist throughout the world and house many poor people. It is therefore important to understand the political, social, and physical factors affecting
development in order to improve shantytown conditions. Earthquakes, floods, droughts, terrorism, poverty, and the COFOPRI national land titling program are the principle forces that contributed to development of Peru’s *pueblos jóvenes*. The case study of Arequipa, Peru helps explain these migration patterns and the shantytown development which resulted. The conditions of loosely constructed homes and animal presence close to bedrooms in Arequipa’s shantytowns promote poverty-associated diseases such as Chagas disease. Thus, addressing underlying poverty concerns would also correct public health problems such as the prevalence of Chagas disease.
CHAPTER 2: QUANTITATIVE ANALYSIS OF T. INFESTANS CHAGAS DISEASE VECTOR IN NUEVA ALBORADA, PERU

INTRODUCTION

Chagas disease is a zoonotic disease considered the sixth-most “neglected tropical disease” in the world as ranked by mortality (Hotez et al., 2006). “Neglected tropical diseases” are chronic infectious diseases that affect rural and urban poor people in developing countries. Although a century has passed since Carlos Chagas discovered the triatomine vector and disease agent of Chagas disease, there are still many facets of the disease that remain mysteries because of its complex epidemiology.

Chagas disease is caused by the parasite Trypanosoma cruzi and is principally transmitted by a triatomine vector, or ‘kissing bug,’ as it is commonly known. Vectorial transmission to humans occurs when the triatomine feeds on the blood of an infected host and then bites a human, passing the parasite through defecation into the wound; the vector-borne route accounts for about 80% of transmission in humans (Beard, 2005). Approximately 50,000 people die from Chagas disease each year with death typically resulting from congestive heart failure (Anonymous, 2006).

Many species of triatomines spread Chagas disease throughout Latin America, but only one triatomine species, Triatoma infestans, transmits the parasite in the area of interest in Arequipa, Peru. Although Chagas disease is historically associated with the rural poor, the domestic T. infestans vector has successfully invaded peri-urban and urban areas (Vallvé et al., 1996 and Levy et al., 2006). Peri-urban areas are defined as regions on the periphery of urban areas, which are often characterized by unplanned growth.
Since Chagas disease is potentially fatal and lacks a vaccine, it is crucial to find ways to prevent it. Drugs are available to treat the acute and early chronic phases of the infection, but the medications have undesirable side effects and are not always effective. Vector control has been a common prevention technique, and the “Southern Cone Initiative,” an intergovernmental effort initiated in 1991 to eliminate T. infestans by insecticide sprayings, was successful in Uruguay, Chile, and Brazil but only regionally successful in Bolivia, Argentina, and Paraguay (Schofield et al., 2006). Peru was part of a similar affiliation called the Andean Countries’ Initiative, a group started in 1997 with the goal of eliminating vectorial Chagas disease transmission from its region by 2010 (Guhl, 2007). One of the biggest challenges is coordinating governmental efforts to systematically control the vectors; without thorough control efforts, reinfestation is likely, especially when homes are close in proximity. Proximity is considered an important factor not only in bugs spreading from one home to another, but also in determining which host species a triatomine chooses to bite (Minter, 1976a).

Because of Chagas disease’s complex epidemiology, it is important to carefully examine all potential risk factors; I have focused on the environmental factors that affect risk. The host species that provide blood meals for triatomines are an important component of the Chagas disease transmission. T. infestans feeds on a variety of mammals and birds, but birds cannot be infected by the T. cruzi parasite, so they play a unique role in Chagas disease epidemiology. Research in the Chaco region of northern Argentina has suggested that during hot weather T. infestans prefer feeding on chickens and dogs over humans when all are present (Gürtler et al., 1997). Dogs and cats also are significantly more infectious to bugs compared to humans making them important reservoir sources of T. cruzi infection (Gürtler
et al., 2007). Because of guinea pigs’ abundance and high infectivity of *T. cruzi*, they occupy a crucial role in the Chagas epidemiology in Bolivia and Peru (Minter, 1976b). Sheep have a *T. cruzi* seroprevalence of approximately 19% (Cetron, 1995). Cattle, pigs, and other large livestock have much lower infectivities to *T. cruzi*, and less research has focused on their role in transmission (Minter, 1976a). However, the importance of pigs in Chagas disease transmission has been suggested by Pizarro and Stevens’ study of *T. infestans* in Bolivia (2008). Studying the factors of host animal competence to *T. cruzi*, *T. infestans* animal preference, and host behavior is important for understanding the role of animals in Chagas disease transmission to humans. The main animals in the literature that are associated with *T. infestans* and Chagas disease are summarized in Table 1.

Survey data from a peri-urban community of Arequipa, Peru allows one to examine explanatory variables of household infestation of *T. infestans*, a likely measure of the risk of contracting Chagas disease. While some Latin American countries have had successful insecticide campaigns to eliminate the *T. infestans* vector, southern Peru still has *T. infestans* vector presence, which is conducive for analyzing spatial patterns of infestation (Fraser, 2008). Arequipa may be representative for other dry areas such as the arid Chaco region of Argentina where the *T. infestans* vector is also present. Examining type and number of household animals in conjunction with socio-economic indicators such as housing type in a spatial analysis allows us to explain why certain houses are more susceptible to infestation than others.
METHODS AND MATERIALS

Study Area

The study was carried out in Nueva Alborada (Figure 2), a peri-urban community of Arequipa, Peru, located at 16.433˚S, -71.492˚W (Levy et al., 2008). This particular region of southern Peru (Figure 1) is arid with rainfall typically only occurring in the months of January through March. From 1997 to 2001 the maximum temperatures ranged between 19.1 and 29.4˚C while minimum temperatures ranged from 6.3 to 13.7˚C (Polk et al., 2005).

Nueva Alborada is one of hundreds of pueblos jóvenes, or shantytowns, on the periphery of Arequipa; the establishment of these squatter communities is intricately related to political and social conditions of Peru’s history. In 1969 radical agricultural reform in Peru triggered a wave of migration of rural residents to peri-urban areas, establishing pueblos jóvenes. Although the reform optimistically aimed to redistribute wealth by eliminating haciendas, it was not very successful in alleviating poverty in the poorest parts of the country, the southern highlands (Klarén, 2000). Continued poverty conditions coupled with low potato prices between 1969 and 1974, a staple highland crop, triggered rural migration of peasants to pueblos jóvenes to seek employment (Klarén, 2000). Violence associated with the Shining Path movement also played a role in continued rural to urban migration patterns in the 1980s (Pease, 1995).

Study Design

This study was carried out in collaboration with the Arequipa Ministry of Health Chagas Disease Control Program (Levy et al., 2008). In July 2006 a preliminary search of consenting households was conducted by entomologic collectors to determine presence or absence of triatomines in peridomestic areas, regions within the homeowner’s lot that are not
part of the daily living space. The collectors used a tetramethrin 0.15% aerosol insecticide to spray for the triatomines. Several months later the Ministry of Health systematically sprayed household rooms, peridomestic areas, and animal enclosures of consenting households with an insecticide treatment of deltamethrin concentrate, which was diluted at a rate of 25 mg/m² (Levy et al., 2008). The insecticide application took place from November 27, 2006 to January 18, 2007 and two triatomine collectors spent a total of one person-hour per household searching for vectors immediately after the spraying. The Chagas research team assisted the Ministry of Health with the bug collection in certain parts of Nueva Alborada. The number of habitants and type of animal (guinea pig, dog, cat, bird, rabbit, sheep, other) were recorded at the time of the spraying. The surveyors noted the type of domestic and peridomestic housing material (sillar (white volcanic rock), stucco, unmortared brick, adobe, other). They also noted the presence of cracks in the material of walls. Triatomines were tested for *T. cruzi* following the protocol described in the study by Gürtler et al (1998).

I conducted five semi-structured interviews with some of the founders of Nueva Alborada in July and August of 2008. The purpose of these interviews was to learn about the history of Nueva Alborada, especially in the context of the establishment of triatomines in the area.

**Data Analysis**

Latitude and longitude coordinates of each house were determined using high-resolution aerial photographs from GoogleEarth (GoogleEarth, 2007). I converted the latitude and longitude coordinates into the Universal Transverse Mercator (UTM) coordinate system (WGS 84, Zone 19 South) to facilitate analysis in meters. I created shapefiles in ArcGIS 9.3 to spatially display the housing and animal types by household.
Because there were many houses without the vector, the outcome variable of number of bugs was not normally distributed. Although there were many small integers containing zeros in the outcome, the Poisson model was not appropriate because the mean and variance were not equal. Statistical analyses were conducted in the statistical package R (R Development Core Team, 2008). I used a two step approach in analyzing the data based on the assumption that there may be two different mechanisms at work: one mechanism that determined whether any triatomines were present or not, and one mechanism that determined how many triatomines were present among houses with a non-zero number of triatomines. First I performed univariate logistic regressions using presence or absence of triatomines as the response, and the animal and housing type (again as presence/absence of that particular animal or housing type) as predictors. Then I ran a backward stepwise selection procedure starting with all predictors to select the best fitting model. The final model was chosen using the lowest Akaike’s Information Criterion (AIC). The second step was an analysis of just the houses with bugs using linear regression and backward stepwise selection on the logarithmically transformed non-zero outcome data. I also tested the correlations between all predictors and the interactions between the significant predictors from the univariate regressions.

I created semi-v variograms of residuals to check for spatial autocorrelation in the residuals for all models. Some models showed evidence of spatial patterns in the data; to account for this I added a predictor variable measuring the distance from each house to the nearest house with 20 or more insects. This metric was calculated using the Distance Between Points function in Hawth’s Analysis Tools for ArcGIS (Beyer, 2004). I then redid the previously mentioned statistical tests including this predictor. In ArcGIS, I also tested
Moran’s I Index and Ripley’s K Function to test for spatial autocorrelation and clustering, respectively. Moran’s I Index is a spatial statistic used to evaluate whether homes with bugs are clustered, dispersed, or random. Ripley’s K Function is another way to test whether the houses with bugs are clustered or dispersed but provides a simpler method for finding the distance to which a feature is clustered. It uses a multi-distance analysis to assess the observed clustering among infested households as compared to what would be expected in randomly distributed infested households.
RESULTS

499 lots were in the community of Nueva Alborada at the time of the insecticide spraying. 452 households participated in the household sprayings; the remaining ones were not sprayed because the lots were either uninhabited, the owners were unavailable, or the owners refused. Owner refusal accounted for only seven of the non-participating households and these homes were randomly distributed. In the community 4,111 total bugs were counted, which were distributed among 165 houses (37% of total). No bugs were infected with T. cruzi. Figure 3 displays a map of the surveyed houses and triatomine presence in the community. The map shows clusters of homes that had bug presence. Households containing 20 or more triatomines are displayed in Figure 4. The cutoff of 20 or more was chosen because of the more significant clustering at this threshold.

Before conducting statistical regressions, the animal category of other, and housing types of peridomestic and domestic adobe, peridomestic and domestic other, unmortared domestic brick, and peridomestic cracks on walls were removed from the data because they either had less than 5 homes in the category or were collinear with another category. The univariate and multivariate regressions were then analyzed in a two step approach: first, a logistic regression of all surveyed houses with a bug presence/absence outcome and second, a linear regression of just the homes with bugs to observe the effect on the outcome of number of bugs.

Presence of guinea pigs, dogs, and distance to a house with 20+ bugs were statistically significantly related to presence of bugs (P<0.05) in univariate logistic regressions of animal type (Table 2), with presence of guinea pigs and dogs associated with a higher odds of bugs being present and the distance to 20+ bugs associated with a slightly
lower odds of bugs present. In the example of the guinea pig predictor, the odds ratio of 2.35 means that a home with guinea pig presence is 2.35 times as likely to have triatomine presence. In the univariate linear regression analyses of animal types, presence of guinea pig, sheep, and bird were positively and statistically significantly related to number of bugs when considering just the homes with triatomines (Table 3). Distance to a house with 20+ bugs was again highly statistically significant. No housing types were statistically significant in the univariate regressions.

After performing stepwise selection of the full logistic model, the significant predictors were guinea pig, dog, and distance to a house with 20 or more triatomines (Table 4). The stepwise selection of the full linear regression produced significant predictors of sheep, cracks in walls of domestic areas, guinea pig, and distance to a house with 20 or more triatomines. Results of the regression are presented in Table 5. In interpreting the two mechanisms underlying the statistical analysis, these results suggest that guinea pig, dog, and distance to a house with 20 or more triatomines are important predictors to determine the presence of triatomines in a house and that sheep, cracks in walls of domestic areas, guinea pig, and distance to a house with 20 or more triatomines are important for determining the amount of triatomines in infested homes.

The Moran’s I Index of spatial autocorrelation was 0.06 on a scale of -1 (dispersion) to 1 (clustering). Z-scores less than -1.96 or greater than 1.96 signify spatial autocorrelation at the 5% significance level. The index had a z-score of 2.08, so there is less than 5% likelihood that the clustering of the homes with bugs is due to chance. Ripley’s K function indicated that infested households were clustered to a distance of approximately 120 meters.
DISCUSSION

The distance from a home to the nearest home with 20 or more triatomines was a highly significant predictor in both univariate and multiple regressions, suggesting that there are clusters, or ‘hotspots,’ of bugs. *T. infestans* bugs are able to crawl up to 42 meters (Vazquez-Prokopec et al., 2004), which would allow them to disperse from one house to another in Nueva Alborada since the households are approximately 10.1 meters apart, on average. This spatial analysis provides anecdotal evidence of a “spread” effect in which bugs from highly infested homes crawl to neighboring homes. Another study which investigated the spatial patterns of reinfestation of *T. infestans* also found distance to infested areas to be significant (McGwire et al., 2006).

The statistical analyses indicate that guinea pigs could also be a potential predictor of *T. infestans* infestation in Nueva Alborada. Guinea pigs are known to be an important factor in Chagas disease epidemiology (Herrer, 1955 and Levy et al., 2006), especially in Peru where they are raised as a food source. Because guinea pigs feed on leftover kitchen scraps, it is easier for poor families to raise them (Rath, B., pers. comm.). Several factors affirm the epidemiological importance of guinea pigs: high abundance, husbandry conditions, high infection rates of *T. cruzi*, and easy transportability (Herrer, 1955 and Minter, 1976b). Families often have a much greater number of guinea pigs compared to other domestic animals. The guinea pigs are often raised in cages, which provide favorable living conditions for *T. infestans*; the cages offer places to hide from the sun, to lay eggs, and to easily access numerous sources of blood meals (Herrer, 1955). Rates of guinea pig infection can reach 60% (as cited in Minter, 1976b and Cetron, 1995). The ease of transporting guinea pigs may also favor the spread of the *T. cruzi* parasite to new areas through migration (Herrer, 1955).
Chickens, turkeys or ducks, represented by the bird predictor in the analysis, may also help to explain the presence of triatomines. According to an experimental study, *T. infestans* preferred feeding on chickens over guinea pigs when both were equally available (Vázquez et al., 1999). Because chickens are blood-meal sources for *T. infestans* and are not susceptible to *T. cruzi* infection, their epidemiological role is unique. While some researchers optimistically hoped that chickens might serve in a zooprophylactic role, one that would decrease the probability of humans being fed upon, this effect has not been scientifically proven. Some studies have indicated a decrease in bug infection rates if *T. infestans* feed exclusively on chickens; however, since *T. infestans* shift between host species that are susceptible to *T. cruzi* infection, the effectiveness of zooprophylaxis is limited (Vázquez et al., 1999 and Gürtler et al., 1998). The presence of domestic chickens may significantly increase the density of domestic *T. infestans* (Cècere et al., 1997), which is confirmed by my results from Nueva Alborada.

Although the sheep variable was a significant predictor in the univariate and stepwise linear regressions, this is not a consistent finding with previous studies. Minter states that the main blood sources for *T. infestans* are humans, chickens, dogs, and cats (1976a). Minter also states that host proximity may be a more important factor in blood source selection than animal preference (1976a). *T. infestans* rarely feed on the larger livestock; in fact, no *T. cruzi* infections of sheep had even been detected at the time of Minter’s study (1976b). One reason for this lack of *T. infestans* blood meals from sheep may be the difficulty of successfully biting a sheep because of the thick wool. Further research in other sites would need to be conducted to see if sheep are associated with house infestation.
Presence of cracks in the wall material of domestic areas was positively and significantly related to the number of bugs in the linear stepwise regression. Because triatomines hide in wall cracks during the day, it makes sense that they would prefer this type of housing. Poor housing conditions are known to be associated with Chagas disease (Zeledón and Rabinovich, 1981). Although presence of wall cracks was the only significant housing predictor in the regressions, it is possible that the dog predictor substituted for some housing types since it was significantly correlated to four of the housing categories. However, these correlation coefficients were small (<0.2).

The maps of infestation show that the southern section of Nueva Alborada was not infested at the time of the spraying. The variables in the model, housing and animal type, did not explain this trend. From talking to residents of Nueva Alborada and others familiar with the area, I know that the southern section is newer, so perhaps the bugs simply had not spread to this region yet. Vector dispersion is common among homes that are close to one another (Levy et al., 2008), so it is likely the bugs will infest the southern region.

Because many elements of Chagas disease transmission are still unknown, a main strength of this study is furthering the understanding the influence of animals, household materials, and spatial factors on vector infestation of \textit{T. infestans} in peri-urban communities. Although no bugs tested positive for \textit{T. cruzi} in Nueva Alborada at the time of the study, other \textit{pueblos jóvenes} in Arequipa have confirmed the presence of the parasite, so implementing preventative tactics is important. However, some limitations of this study restrict the extent to which the results can be used to predict infestation in other areas. Because the study was conducted in a small site with specific climatic conditions and domestic animal behaviors, the findings may not accurately be generalized to other sites.
Since the researchers assisted with the bug collection in certain parts of Nueva Alborada, some sampling bias exists in the data. Simple data on presence or absence of animals was recorded in the surveys, so the analysis neglects the effect of animal abundance on bug infestation. Also, the bug populations may not accurately correspond to the surveyed animals but may be an effect of animals no longer present (Levy et al., 2006).

Precise prevalence rates of Chagas disease are not known for Arequipa since large-scale surveys have not been conducted. However, a survey in one peri-urban community of Arequipa indicated a 5.3% rate of infection of 2-18 year old children (Levy et al., 2007). Presence of *T. cruzi* in the human population coupled with domestic animals and household infestation of triatomines in the *pueblos jóvenes* of Arequipa facilitates Chagas disease transmission; thus, it is important to have an effective strategy to minimize the disease risk. Insecticide treatments are quite effective in ridding households of *T. infestans*, but they are a short-term solution since reinfection from neighboring communities is likely. Some more sustainable preventative approaches include preventing domestic animals from sleeping in the same room as people, stuccoing walls, and educating communities about Chagas disease (Cohen and Gürtler, 2001).

To advance the understanding of Chagas disease prevention, future studies might address the host competence of sheep and other large livestock to *T. cruzi* and their association with *T. infestans* infestation. The presence of chickens should continue to be studied for its potential zooprophylactic effect when other animals are excluded from domestic household areas. A comparative study between Nueva Alborada and a neighboring *T. cruzi*-positive community would be a useful analysis because it could provide insight regarding why only some communities have the parasite.
CONCLUSION

This thesis has shown how examining household survey information combined with interview data can explain the risk factors involved with Chagas disease in pueblos jóvenes of Peru. Chapter 1 examined the social and political background of periurban areas in Peru, especially Arequipa, in order to contextualize Chagas disease emergence in pueblos jóvenes. Interviews with community founders of several pueblos jóvenes of Arequipa revealed historical information about how these pueblos jóvenes formed and what the residents understand about the Chagas disease vector. Focusing on household survey data from one such periurban community, Nueva Alborada, indicated how household characteristics such as cracks in walls and the presence of guinea pigs and dogs are statistically significant determinants of the presence of the vector of Chagas disease in southern Peru, Triatoma infestans.

Many challenges face eradication of Chagas disease: it has no vaccine, treatment of the disease is complicated with undesirable side effects, and reinfestation of homes with T. infestans following insecticide treatment is common. Given these challenges, there is a need for affordable, sustainable prevention techniques. As the results from Chapter 2 show, prevalence of the T. infestans vector is correlated with the presence of dogs and guinea pigs; thus, restricting dogs and guinea pigs from bedrooms might help reduce the number of triatomines likely to bite humans. Sealing wall cracks is another effective prevention strategy. Nueva Alborada is representative of other pueblos jóvenes and this analysis provides an example of how the distribution of the T. infestans Chagas disease vector can analyzed with the goal of informing prevention efforts.
Figure 1. Map of Peru showing location of Arequipa.
Figure 2. High-resolution Google Earth aerial photograph of the study site, Nueva Alborada.
Figure 3. Map of 452 surveyed homes in the peri-urban community of Nueva Alborada, Peru. Red dots indicate homes with one or more triatomines. Spatial patterns of infestation are suggested by the clusters of homes with triatomines. The southern region had no bugs, which may be because this section of Nueva Alborada is newer.
Figure 4. Households in Nueva Alborada with 20 or more triatomines indicated by green points, which displays infestation clusters. Homes with 20 or more bugs are significantly clustered together; this suggests that houses with large numbers of bugs may spread from one house to another.
Table 1. Summary of prominent animals associated with blood meals of *T. infestans* vector of Chagas disease in scientific literature.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Sample Citations</th>
<th>Recorded in Nueva Alborada study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog</td>
<td>(Minter, 1976a), (Cohen and Gürtler, 2001), (Gürtler et al., 2007)</td>
<td>*</td>
</tr>
<tr>
<td>Cat</td>
<td>(Minter, 1976a), (Wisnivesky-Colli et al., 1985), (Gürtler et al., 2007)</td>
<td>*</td>
</tr>
<tr>
<td>Guinea pig</td>
<td>(Herrrer, 1955), (Minter, 1976b), (Levy et al, 2006)</td>
<td>*</td>
</tr>
<tr>
<td>Chicken or bird</td>
<td>(Minter, 1976b), (Vázquez et al., 1999), (Cohen and Gürtler, 2001)</td>
<td>*</td>
</tr>
<tr>
<td>Human</td>
<td>(Minter, 1976a), (Wisnivesky-Colli et al., 1985), (Cohen and Gürtler, 2001)</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>(Minter, 1976a), (Cècere et al, 2004), (Marsden et al., 1979)</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>(Minter, 1976b), (Gürtler et al., 1996), (Gürtler et al., 1997)</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>(Minter, 1976b), (Gürtler et al., 1996), (Gürtler et al., 1997)</td>
<td>*</td>
</tr>
<tr>
<td>Pig</td>
<td>(Minter, 1976b), (Gürtler et al., 1997), (Marsden et al., 1979)</td>
<td></td>
</tr>
<tr>
<td>Horse</td>
<td>(Minter, 1976b), (Gürtler et al., 1997), (Marsden et al., 1979)</td>
<td></td>
</tr>
<tr>
<td>Bat</td>
<td>(Minter, 1976a), (Minter, 1976b), (Zeledón and Rabinovich, 1981)</td>
<td></td>
</tr>
<tr>
<td>Rodent</td>
<td>(Minter, 1976a), (Zeledón and Rabinovich, 1981), (Guarneri et al., 2000)</td>
<td></td>
</tr>
<tr>
<td>Opossum</td>
<td>(Minter, 1976a), (Zeledón and Rabinovich, 1981), (Gürtler et al., 2007)</td>
<td></td>
</tr>
<tr>
<td>Pigeon</td>
<td>Pilot interviews with local informants</td>
<td></td>
</tr>
</tbody>
</table>

**Other animal variables in the Nueva Alborada study included rabbit and other.**
Table 2. Logistic regression of animal type predictors of infestation among all surveyed homes of Nueva Alborada, Peru.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Odds Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guinea Pig</td>
<td>2.35</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dog</td>
<td>2.26</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance to 20+ bugs</td>
<td>0.94</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(meters)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Linear regression of animal type predictors of infestation among infested homes of Nueva Alborada, Peru.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Intercept</th>
<th>Slope</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guinea Pig</td>
<td>17.88</td>
<td>18.13</td>
<td>0.0028</td>
</tr>
<tr>
<td>Sheep</td>
<td>2.17</td>
<td>1.44</td>
<td>0.019</td>
</tr>
<tr>
<td>Bird</td>
<td>2.036</td>
<td>0.51</td>
<td>0.033</td>
</tr>
<tr>
<td>Distance to 20+ bugs</td>
<td>2.95</td>
<td>-0.044</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(meters)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Stepwise selection of logistic multiple regression. 451 total degrees of freedom.

Residual deviance = 386. AIC = 398.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient Estimate</th>
<th>Odds Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guinea pig</td>
<td>1.14</td>
<td>3.09</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dog</td>
<td>0.92</td>
<td>2.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance from 20+ bugs (meters)</td>
<td>-0.066</td>
<td>0.94</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 5. Stepwise selection of houses with triatomines with linear multiple regression. AIC = 53.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.026</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>0.87</td>
<td>0.072</td>
</tr>
<tr>
<td>Cracks in walls of domestic area</td>
<td>0.58</td>
<td>0.015</td>
</tr>
<tr>
<td>Guinea pig</td>
<td>0.69</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance from 20+ bugs (meters)</td>
<td>-0.044</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
APPENDIX A: Informe para el Centro de Salud de Nueva Alborada

La enfermedad de Chagas es una enfermedad zoonótica que es causada por el parásito *Trypanosoma cruzi* y es transmitida principalmente por un vector, conocido científicamente como una “triatomina” y coloquialmente como “la chirimacha.” Además de la forma vectorial, los modos de transmisión incluyen la manera congénita (de madre a hijo), por transfusiones de sangre y por trasplantes de órganos. La transmisión por vector ocurre cuando la chirimacha pica un animal infectado con el parásito y después pica un ser humano pasando el parásito cuando defeca en la picadura.

En Latinoamérica, muchas especies de triatomina pueden transmitir la enfermedad de Chagas, pero la única especie que la transmite en la parte sur del Perú es *Triatoma infestans*. *Triatoma infestans* es un vector doméstico que anteriormente se encontraba principalmente en áreas rurales, y en la actualidad ha invadido áreas urbanas y periurbanas. Tratar comunidades con insecticida puede ser efectivo para controlar poblaciones de chirimachas, pero la reinfestación es un problema que puede presentarse, especialmente cuando las casas están muy cerca unas de otras.

La epidemiología de la enfermedad de Chagas es muy compleja y es indispensable entender los factores que intervienen en esta. Las especies de huésped que proveen sangre como alimento para las chirimachas son un elemento importante en la transmisión de la enfermedad de Chagas. *T. infestans* pica varios tipos de mamíferos y aves, pero los aves no se infectan con el parásito. Los cuyes tienen un papel crucial en la epidemiología de Chagas en Perú debido a su abundancia y al alto índice de infectividad del parásito *T. cruzi*.

Las encuestas de casa que hizo el Ministerio de Salud en la comunidad de Nueva Alborada nos dan elementos para entender variables que pueden estar relacionadas con la
infestación de *T. infestans*. En julio de 2006 una búsqueda preliminar de casas fue realizada por recolectores entomológicos para determinar la presencia o ausencia de chirimachas en áreas peridomésticas. Los recolectores usaron un insecticida de 0.15% tetramethrin para rociar las chirimachas. Algunos meses después, entre el 27 de noviembre, 2006 y 18 de enero, 2007, el Ministerio de Salud roció los cuartos, las áreas peridomésticas y los corrales con un insecticida de deltamethrin, diluido a una tasa de 25 mg/m$^2$; luego dos recolectores al mismo tiempo pasaron una hora en cada casa buscando las chirimachas. Se anotó el número de habitantes, el tipo de animales (cuy, perro, gato, ave, conejo, ovejo, otro) y el tipo de material usado en la construcción de las casas (sillar, noble, ladrillo sin estucar, adobe, grietas, otro).

Al tiempo del rocio, había 499 lotes en Nueva Alborada y 452 casas participaron en el rocio; los demás no participaron por diversas razones tales como renuencia de sus habitantes y casas cerradas o deshabitadas. Se tuvo un conteo de 4,111 chirimachas en la comunidad, las cuales estuvieron distribuidas entre 165 casas (37%). Los resultados del análisis sugieren que cuyes, aves, perros, ovejas y grietas en áreas domésticas son factores asociados con infestación de *Triatoma infestans*. La distancia entre una casa infestada con 20 o más chirimachas a otra casa, también es muy significativa en explicar la infestación que sugiere que las casas muy infestadas contribuyen a la dispersión de las chirimachas.

Las tasas de prevalencia de la enfermedad de Chagas no son exactas para Arequipa porque no se han hecho encuestas de gran envergadura. Sin embargo, una encuesta en una comunidad periurbana de Arequipa señaló una tasa de infección de 5,3% entre niños de 2-18 años (Levy et al., 2007). La presencia de *T. cruzi* en la población humana junto con animales domésticos e infestación de chirimachas en los pueblos jóvenes crea las condiciones
propicias, que favorecen la transmisión de la enfermedad de Chagas. Por lo tanto, es
importante tener una estrategia efectiva para minimizar el riesgo de contraer la enfermedad.
Además del control de vectores por el uso de insecticidas, algunos enfoques preventivos
incluyen evitar que los animales domésticos dueran en el mismo cuarto que las personas,
sellar las paredes y pisos y educar las comunidades sobre la enfermedad de Chagas.

Referencias
Levy, MZ, Quispe-Machaca VR, Ylla-Velasquez JL, Waller LA, Richards JM, Rath B,
Borrini-Mayori K, Cornejo del Carpio JG, Cordova-Benazaquen E, McKenzie FE, Wirtz
RA, Maguire JH, Gilman RH, Bern C, 2008. Impregnated netting slows infestation by

Glosario
enfermedad zoonótica – una enfermedad que puede pasar de un animal a una persona
huésped – un animal o persona en que puede vivir el parásito
Triatoma infestans – el nombre científico de la chirimacha
Trypansoma cruzi – el nombre científico del parásito que causa la enfermedad de Chagas
vector – un insecto u otro organismo que lleva el parásito de un animal a otro (la chirimacha
es el vector en el caso de la enfermedad de Chagas)
Mapa de Nueva Alborada

*Las casas marcadas representan las que estuvieron encuestadas y rociadas entre noviembre 2006 y enero 2007.

**Leyenda**
- Centro de Salud
- Casas con chirimachas
- Casas sin chirimachas

0 150 300 (metros)
APPENDIX B: SEMI-STRUCTURED INTERVIEW QUESTIONS (SPANISH)

1. ¿En qué año empezó usted a vivir en (nombre del pueblo joven)?

2. ¿Cómo era la ciudad en esta época? (¿Cuántas personas vivían allí?, ¿Cultivos? ¿Vegetación?)

3. ¿Cuándo fundaron (nombre del pueblo joven)?

4. ¿Quién era el dueño de la tierra antes?

5. ¿Cuándo y cómo dividieron la tierra?

6. ¿Recibió apoyo del banco de materiales?

7. ¿Tiene un título de propiedad?

8. ¿Cuándo empezaron a tener perros en los lotes? ¿Y otros animales domésticos?

9. ¿Cómo ha cambiado el área mientras usted ha vivido aquí?

10. ¿Qué sabe usted acerca de las chirimachas?

11. ¿Puede describir la presencia de chirimachas en Nueva Alborada? (¿Cuándo aparecieron? ¿Cómo aparecieron?)

12. ¿El número de chirimachas está cambiando?

13. ¿Cree que podría ser una conexión entre los cambios aquí y la presencia de chirimachas? (ej: cuando empezaron a tener gallinas)

14. ¿Qué cree que ha favorecido la presencia de chirimachas acá?
1. What year did you begin living in (name of community)?

2. What was the community like at this time? (How many people were living in the area? Crops? Vegetation?)

3. When was (name of community) founded?

4. Who was the former owner of the land?

5. When and how was the land divided?

6. Did you receive help from the “material bank”?

7. Do you have a land title?

8. When did people begin to have dogs in their lots? Other domestic animals?

9. How has the area changed since you have lived here?

10. What do you know about ‘kissing bugs’?

11. Can you describe the presence of ‘kissing bugs’ in (name of community)? (When did they appear? How did they appear?)

12. Is the number of ‘kissing bugs’ changing?

13. What do you think might be a connection between the changes here and the presence of ‘kissing bugs’? (ex: when people began to have chickens)

14. What do you think has favored the presence of ‘kissing bugs’ in the community?
### APPENDIX D: LIST OF INTERVIEWEES

<table>
<thead>
<tr>
<th>Name</th>
<th>Community of residence</th>
<th>Date of interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eusebia Laura</td>
<td>Nueva Alborada</td>
<td>July 15, 2008</td>
</tr>
<tr>
<td>Vicenta</td>
<td>Nueva Alborada</td>
<td>July 15, 2008</td>
</tr>
<tr>
<td>Jesús Cardenas</td>
<td>Nueva Alborada</td>
<td>July 20, 2008</td>
</tr>
<tr>
<td>Julian Cruz</td>
<td>Nueva Alborada</td>
<td>July 20, 2008</td>
</tr>
<tr>
<td>Cristóbal Mamani Zapana</td>
<td>Villa Los Pinos</td>
<td>July 20, 2008</td>
</tr>
<tr>
<td>Armando Lopez</td>
<td>Santa Maria I</td>
<td>July 23, 2008</td>
</tr>
<tr>
<td>Vilma Titi</td>
<td>Santa Maria I</td>
<td>July 23, 2008</td>
</tr>
<tr>
<td>Lourdes Mamani Roque*</td>
<td>Santa Maria I</td>
<td>July 23, 2008</td>
</tr>
<tr>
<td>Humberto Quispe Tito</td>
<td>Santa Maria I</td>
<td>July 23, 2008</td>
</tr>
<tr>
<td>Juana Chullo Pumacota*</td>
<td>Santa Maria II</td>
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*indicates interviewees who were *promotoras de salud*, volunteer health promoters
REFERENCES

[Anonymous], 2006. Chagas’ disease - an epidemic that can no longer be ignored. 


Rath, B. E-mail interview. 5 June 2009.


