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Assessing the Chagas Disease Risk Among the Homeless Population of Houston, Texas

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Assessing the Chagas Disease Risk Among the Homeless Population of Houston, Texas

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An abstract of
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Master of Public Health
in Global Health
2014

Abstract

Assessing the Chagas Disease Risk Among the
Homeless Population of Houston, Texas
By Alexandra Ingber

Background: Chagas disease (American Trypanosomiasis) is a parasitic infection endemic to Latin America and is caused by infection with *Trypanosoma cruzi*. The most common route of infection is by the triatomine vector. The vector is now present in the United States exposing vulnerable populations, such as homeless individuals spending prolonged time outdoors, for potential risk of infection.

Goal: The goal of this research is to address the gap in knowledge about risk of Chagas disease among vulnerable populations in the United States and investigate the risk of Chagas disease among Houston's homeless population participating in previously identified high-risk behaviors and quantify their knowledge through quantitative questionnaires.

Methods: A quantitative questionnaire was written and administered to 212 homeless individuals in Houston, Texas to investigate demographics, health status, knowledge about Chagas disease, and risky behaviors such as sharing of needles, blood transfusions, and length of time spent outdoors. Statistical analyses were conducted to quantify the risk of Chagas disease among the homeless population of Houston.

Results: A majority of those surveyed were male (79%), African-American (43%), American-born individuals (96%) using the Emergency Department as their primary source of healthcare (74%). About 30% of respondents recognized a picture of the triatomine, and 5 individuals believed they had been bitten by the triatomine. More than a quarter of respondents identified engaging in risk behaviors, including unregulated tattoos and using needles to inject drugs. The median total length of time homeless was different for males and females surveyed. The median total time homeless for male respondents was 104 weeks (2 years) and for female respondents was 76 weeks (1.5 years). In the epidemiological model, having chest pain in the past year was a significant predictor; those who did have chest pain were less likely (OR = 0.031 95% CI 0.001, 0.828) to believe they have been bitten by the triatomine than those without chest pain.

Discussion: Based on these findings, the homeless population could be at higher risk for Chagas disease in the Houston area due to the total length of time homeless and nights sleeping outside as well as high-risk behaviors for spreading pathogens in the blood such as injection drug use and unregulated tattoos. Additional research is necessary to quantify the exact prevalence of Chagas disease among the homeless population. Education about Chagas disease transmission and reducing risky behaviors should be disseminated to homeless populations, shelter directors, and medical providers.

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LITERATURE REVIEW

Research Need and Goal

There is a clear need to understand the risk of Chagas disease here in the United States. *Trypanosoma cruzi* infected vectors inhabit the southern United States,[1] vulnerable populations associated with poverty also live in these areas and may come in contact with the vector outdoors,[2] and subpopulations often engage in risky behaviors[3] associated with transmission of pathogens through infected blood, such as *T. cruzi*. More attention is needed to investigate the risk of vulnerable groups, such as homeless populations and Hispanic immigrants.

The goal of this research is to address this need and investigate the risk of Chagas disease among Houston's homeless population participating in previously identified high-risk behaviors and quantify knowledge about Chagas disease through questionnaires. The research first aims to quantify the knowledge of Chagas disease (i.e. identification and recognition of triatomine and recognition of the name "Chagas disease") among Houston's homeless population. Second, the research will quantify the participation in and frequency of previously identified risk behaviors (e.g. from literature reviews and key informant interviews) associated with Chagas disease among Houston's homeless population such as unregulated tattoos, blood transfusions before 2007, sharing of

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1 Bern, Caryn et al. "*Trypanosoma* cruzi and Chagas' Disease in the United States." Clinical Microbiology Reviews. 24:4:655-681. Oct 2011

2 University of Texas at Austin. "Texas Politics". Liberal Arts Instructional Technology Services. 3rd Edition, Revision 102. 2014.

3 Noor S, Ross M, Lai D, Risser J. "Clustered Drug and Sexual HIV Risk Among A Sample of Middle-Aged Injection Drug Users, Houston, Texas." *AIDS Care*. 25:7:895-901. 2013.

injection drug materials, and sleeping outdoors. Third, by surveying within the homeless population of Houston, this research will seek to determine if there is an association between any of these previously identified risk behaviors and the level of knowledge about Chagas diseases among the homeless population of Houston. Lastly, the aims of this research will help to propose policy solutions for the gaps in knowledge, testing, and identification of Chagas disease in the United States, especially in Houston among the homeless.

Chagas Disease Transmission, Symptoms, Testing, and Treatment

Chagas disease can be acquired by vector-borne transmission through the triatomine, or commonly called 'kissing bugs'. Dozens of species of triatomines are known to inhabit the areas from the southern United States to southern Argentina.[4,5] Vector transmission is most common where houses are made from mud, straw, or adobe, which are often associated with poverty and poorly constructed homes in rural and suburban areas. Triatomines hide in crevices of the walls, remain mostly inactive during the daytime hours, and emerge at night.[6] After an infected triatomine feeds on a blood meal from a mammalian source, it often simultaneously defecates on the wound leaving behind feces containing parasites. When a person scratches the bite or rubs their eyes or mouth, the parasite can enter the body. Chagas disease can also be transmitted congenitally from mother to baby, by consuming foods contaminated with feces containing parasites, blood

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[4] Noor, Ibid.

[5] Filho, Oliveira. "Differences of Susceptibility of Five Triatomine Species to Pyrethroid Insecticides-Implications for Chagas Disease Vector Control." *Mem Inst Oswaldo Cruz*. 94:1:425-428. 1999.

[6] World Health Organization. "Chagas Disease (American Trypanosomiasis)" Fact Sheet Nº340. March 2013.

transfusions from infected individuals, and organ transplants from individuals with the *T. cruzi* parasite in their blood (reviewed in [7]).

The symptoms exhibited in the acute phase of the disease, after immediate infection, are often unknown to the person or very mild. Of those infected with the parasite, 10-30% will develop non-specific symptoms associated with the acute phase and many will not know they are infected. Non-specific symptoms include general malaise, low-grade fever, and swelling of the bite site.[8] Less than 5% of acute Chagas disease cases result in death, and often these cases are among children under five and immunocompromised individuals.[9] Of those infected, 70-90% become carriers of the disease or in the "indeterminate phase", and because of their unknown status, can transmit Chagas through pregnancy and organ and blood donation. About 30% of individuals will progress from the indeterminate phase to the symptomatic chronic phase, experiencing cardiac (Chagas cardiomyopathy) or gastrointestinal complications (reviewed in [10]).

There are no universally accepted diagnostic procedures for detecting *T. cruzi* infection, and reliability of the tests differs based on strain of *T. cruzi* parasite. However, diagnosis during the acute phase can be made through direct microscopy and visualization of the parasite in the blood. During the indeterminate and chronic phases, parasites may be circulating in the blood at a low enough level that direct microscopy and visualization of the parasite may not be possible. Often, serologic tests for the *T. cruzi* antibody are used

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[7] CDC. "Epidemiology & Risk Factors." Parasites- American Trypanosomiasis. 19 Jul 2013.
[8] Klein, Nicole et al. "Globalization of Chagas Disease: A Growing Concern in Nonendemic Countries." *Epidemiologic Research International*. 30 Aug 2012. 2012:1-13.
[9] CDC. "Parasites- American Trypanosomiasis." Global Health, Division of Parasitic Diseases and Malaria. 19 Jul 2013.
[10] CDC, 2013. Ibid.

to make a diagnosis, especially in the chronic phase when the parasite cannot be visualized by direct microscopy. However, two or more tests such as enzyme linked immunosorbent assay (ELISA) and immunoflourescence (IFA) are needed to make a confirmatory diagnosis due to the sensitivity of the tests.[11] A rapid test, the Chagas Stat-Pak, is commercially available but sensitivity and specificity differ depending on the *T. cruzi* strain. In Argentina, the Stat-Pak has 95.3% sensitivity and 99.5% specificity in comparison to the accepted reference test, the Ortho *T. cruzi* ELISA produced by Johnson & Johnson.[12] Radioimmunoprecipitation assay (RIPA) is currently considered the gold standard confirmatory test, but is not used as the only or primary method of testing.[13]

Currently, the two most common anti-parasitic treatments for Chagas disease in the acute phase are Benznidazole and Nifurtimox. Treatment is currently recommended for individuals in the acute phase of Chagas disease, children eighteen years or younger in the chronic phase, and congenital infections. Once Chagas cardiomyopathy is apparent, recommendation is for treatment of symptoms. However, adults younger than fifty years old who have not yet progressed to cardiac symptoms may also be treated with anti-parasitic drugs.[14] Although these drugs are approved for use in endemic countries, neither Benznidazole nor Nifurtimox are Food and Drug Administration (FDA) approved. Patients can receive these drugs through the Centers for Disease Control and Prevention

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[11] Barfield, CA et al. "A Highly Sensitive Rapid Diagnostic Test for Chagas Disease That Utilizes a Recombinant Trypanosoma cruzi Antigen." *IEEE Trans biomed Eng.* 58:3:814-817. Mar 2011.

[12] Barfield, Ibid.

[13] Afonso, Anna, Mark Ebell, and Rick Tarleton. "A Systematic Review of High Quality Diagnostic Tests for Chagas Disease." *PLoS Neglected Tropical Diseases*. 6:11. 8 Nov 2012.

[14] Centers for Disease Control and Prevention. "Antiparasitic Treatment." Parasites: American Trypanosomiasis. 19 Jul 2013.

(CDC) under investigational protocols, but this must occur through a licensed physician and agreement between the patient, physician, and CDC.[15]

Chagas Disease in Non-Endemic Countries

With global climate change and an increase in immigration, *T. cruzi* infected vectors and humans are migrating around the world causing previously non-endemic countries to suffer from a high burden of Chagas disease cases (reviewed in [16]). In non-endemic countries, as individuals move from the chronic indeterminate phase to Chagas cardiomyopathy, healthcare can become expensive and create an extra burden on the healthcare system of these non-endemic countries.[17] Annually, the global healthcare costs associated with Chagas diseases are about $627.46 million USD with about 10% of these costs assumed by the United States where Chagas is not known to be endemic.[18] There are currently no estimates of the economic burdens and costs of Chagas disease in non-endemic countries.[19] However, the burden can be represented in the prevalence of *T. cruzi* among immigrant populations. For example, in Spain, a country where the triatomine vector does not live, Chagas disease has become a public health issue weighing on the healthcare system. A study conducted at a primary healthcare setting in Barcelona, Spain identified the prevalence of Chagas disease among Bolivian immigrants

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[15] CDC, Ibid.

[16] Colwell D, Dantas-Torres F, Otranto D. "Vector-borne Parasitic Zoonoses: Emerging Scenarios and New Perspectives." *Veterinary Parasitology*. 182:14-21. 2011.

[17] Lee B, Bacon K, Hotez P, et al. "Global Economic Burden of Chagas Disease: a Computational Simulation Model." *The Lancet Infectious Diseases*. 13:4:342-348. Apr 2013.

[18] Lee, Ibid.

[19] Gascon J, Bern C, Pinazo MJ. "Chagas Disease in Spain, United States, and Other Non-Endemic Countries." *Acta Tropica*. 115:22-27. 2010.

to be 16.5%.[20] Similarly, a country that previously was unknown to have Chagas disease like Switzerland may now have people at risk of acquiring Chagas through the healthcare system when receiving blood transfusions or organ donations. Individuals who are unaware of their infection by *T. cruzi* may continue to donate blood and organs putting others at risk. A study conducted in Geneva, Switzerland, which is a country that is not a habitat for the triatomine but has immigrants from Latin America, found that 12.8% of individuals recruited for the study had two positive serologic tests for *T. cruzi* (n = 1012). Of the individuals with Chagas disease, 17% (22 individuals) had already donated blood in the Swiss healthcare system. If the other patients had not been diagnosed with Chagas disease, 19% (24 individuals) of these individuals were considering donating blood and 26% (34 individuals) were considering donating organs in the future.[21] Chagas disease is becoming a burden in countries that were not previously endemic and can potentially cause a financial strain on the healthcare system due to Chagasic cardiomyopathy.

However, the United States is unique because it is a country that may be transitioning from a non-endemic country to an endemic country due to immigration and infected triatomine vectors (reviewed in [22]). Unlike Spain and Switzerland, two countries with a growing burden of Chagas Disease, the United States is unique because not only is there an increase in immigration from Latin America but also because the triatomine vector infected with *T. cruzi* inhabits the southern United States. Those that develop cardiac symptoms often do not exhibit symptoms until decades after infection. Symptomatic

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[20] Roca C, Pinazo MJ, López-Chejade P, Bayó J, Posada E, et al. "Chagas disease among the Latin American adult population attending in a primary care center in Barcelona, Spain." *PLoS Negl Trop Dis*. 2011:5:e1135.

[21] Jackson Y, Getaz L, Wolff H, et al. "Prevalence, Clinical Staging and Risk for Blood-Borne Transmission of Chagas Disease Among Latin American Migrants in Geneva, Switzerland." *PLoS Negl Trop Dis.* 2 Feb 2010.

[22] Bern, *Trypanosoma* cruzi and Chagas' Disease in the United States." 2011.

individuals are presenting to medical systems not in their original country of infection but in their new host country because of a long lapse in time between infection and symptoms, which causes an increased burden in non-endemic countries.[23] Individuals are not only arriving in the United States with *T. cruzi* infection, but it is suspected that infections can occur in the United States from the triatomine vector.

The majority of Chagas disease cases diagnosed in the United States are among Latin American immigrants who acquired *T. cruzi* infection in their country of origin but are now living in the United States. It is estimated that as of 2011, about 18.8 million immigrants in the United States reported having been born in a Latin American country. This is about 47% of the total US immigrant population.[24] For example, a study in New York City enrolled 39 Hispanic immigrants with dilated cardiomyopathy to test for *T. cruzi*. Participants' origins included twelve different Latin American countries. Of the 39 participants, 13% were infected with *T. cruzi*. None of these participants knew about their infection with *T. cruzi* before this study.[25] Based on immigrant population estimates and prevalence estimates, Caryn Bern and Susan Montgomery of the CDC have projected that there are a total of 300,167 *T. cruzi* infected individuals in the United States.[26] Immigration is one factor leading to an increase of Chagas disease burden in the United States. Bern et al. discusses that in Latin American countries where recognition of Chagas disease is much higher, cases still go undiagnosed; in the United States, where

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[23] Rassi A, Rassi A, Marin-Neto JA. "Chagas Disease." *The Lancet*. 375:9723:17-23. Apr 2010.

[24] Britz E, Batalova J. "Frequently Requested Statistics on Immigrants and Immigration in the United States." *Migration Policy Institute.* 31 Jan 2013.

[25] Kapelusznik L, Varela D, Montgomery S, et al. "Chagas Disease in Latin American Immigrants With Dilated Cardiomyopathy in New York City." *Clinical Infectious Diseases*. 57:1. 28 Mar 2013.

[26] Bern C, Montgomery S. "An Estimate of the Burden of Chagas Disease in the United States." *Clinical Infectious Diseases*. 49:5. Sept 2009.

recognition and diagnosis of Chagas disease is much lower, it is likely that both autochthonous and non-autochthonous cases are undetected.[27]

Similarly, only seven autochthonous human cases via the triatomine vector have been diagnosed and documented in the United States, specifically four cases in Texas and one case each in California, Tennessee, and Louisiana.[28] None of the individuals had any history of travel to endemic locations. These are the only cases documented as acquired in the United States since 1955, indicating that this may be an underreporting of cases domestically acquired due to lack of diagnosis. Uniform diagnostic techniques do not exist, and many medical care providers may not recognize the symptoms of Chagas disease thus potentially failing to identify additional cases. In each of these cases, healthcare was sought due to the presence of symptoms or the visualization of the triatomine. For example, the fifth autochthonous case confirmed occurred in an 18-month old child living in rural Tennessee. The mother found the triatomine in the crib, saved the insect, and a laboratory was able to confirm the presence of *T. cruzi* in both the insect and child. The child had never traveled to an endemic location; the presence of both the triatomine infected *T. cruzi* and engorged with the child's blood after finding the triatomine in the child's crib confirmed the origin of infection. This showed direct infection of the child from the triatomine, indicating that triatomines are present in the southern United States and potentially causing *T. cruzi* infection among humans.[29]

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[27] Bern, 2011. Ibid.

[28] Bern. "Trypanosoma cruzi and Chagas' Disease in the United States." 2011.

[29] Herwaldt B, Grijalva M, Newsome A, McGhee C, et al. "Use of Polymerase Chain Reaction to Diagnose the Fifth Reported US Case of Autochthonous Transmission of *Trypanosoma cruzi*, in Tennessee, 1998."*Journal of Infectious Disease*. 181:1:395-399. Jan 2000.

Chagas disease and the triatomine vector are increasingly identified in the United States, especially southern states such as Arizona, Louisiana, and Texas. The triatomine vector distribution is dependent on the species, but a majority of triatomines are identified in the southern states.[30] A sample of 140 triatomines was collected from three military bases (Camp Bullis, Fort Sam Houston, and Lackland Air Force Base) around San Antonio, Texas. Four different species were identified: *Triatoma gerstaeckeri, T. sanguisuga, T. lectiularia, and T. indictiva*. Triatomines infected with *T. cruzi* parasite were only found at Lackland Air Force Base where 16% of collected triatomines were infected.[31] Similarly, a study that pooled together triatomine specimens, both preserved and newly collected, identified that triatomines inhabited 38% of counties in Texas (97 of 254 counties) and infected triatomines inhabited 19% of counties (48 counties). 241 specimens were newly collected, and 51% of these were infected with *T. cruzi*. Almost all of the infected triatomines were collected inside or near houses putting humans at risk for a domestic transmission cycle in Texas.[32]

Domestic Transmission Cycle in Stray Dogs and Mammals in Texas

A natural domestic transmission cycle and enzootic transmission of *T. cruzi* occurs in Texas, especially among mammalian reservoirs such as the southern plains woodrats. In a study conducted to assess the prevalence of *T. cruzi* in mammalian reservoirs in Southern Texas, it was found that 75% of striped skunks (n=4), 60% of raccoons (n=20), 34% of woodrats (n=104), and 18% (n=28) of all other rodents such as squirrels, house mice, and

[30] Bern, *Trypanosoma* cruzi and Chagas' Disease in the United States." 2011.

[31] McPhatter, L. et al. "Vector Surveillance to Determine Species Composition and Occurrence of Trypanosoma cruzi at Three Military Installations in San Antonio, Texas."

[32] Kjos S, Snowden K, Olson J. "Biogeography and *Trypanosoma cruzi* Infection Prevalence of Chagas Disease Vectors in Texas, USA." *Vector-Borne and Zoonotic Diseases*. 9:1:41-49. 2009.

cotton rats were infected with the *T. cruzi* parasite.[33] This cycle continues to expand to other species and has since begun to include both stray and domestic canines that spend a majority of their lives outdoors.

Both stray and domestic canines, especially of the sporting and herding groups often used for hunting, are now included in the domestic transmission cycle of *T. cruzi* in Texas (reviewed in [34]). A total of 537 confirmed cases of *T. cruzi* infection among domestic canines have been documented in a total of 48 counties in Texas. The infection was not limited to specific breeds but did disproportionately affect canines in the sporting and herding groups (e.g.: spaniels, retrievers, shepherds) because these dogs tend to spend more time outdoors increasing risk of exposure. In confirmed cases, 98% of the canines had myocarditis and in 82% direct observation of the *T. cruzi* parasite was possible.[35] Canines, like woodrats and raccoons, are now exposed to the triatomine bug and at risk for infection by *T. cruzi* due to the amount of time spent outdoors.

Similarly, a concern about the domestic transmission cycle of *T. cruzi* in canines arose when US Army veterinarians began seeing an increase of Chagas cases among military working dogs in three military bases near San Antonio, Texas. A cross-sectional study was performed to evaluate the seroprevalence of *T. cruzi* among the military working dogs housed in kennel facilities on the bases. The dogs had a seroprevalence of 8%. The military working dogs had been trained on these three bases and had not yet left to serve in other areas of the world. This indicates, along with the collection of triatomines in the

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[33] Charles R, Kjos S, Ellis A, Barnes J, Yabsley M. "Southern Plains Woodrats (*Neotoma micropus*) From Southern Texas Are Important Reservoirs of Two Genotypes of *Trypanosoma cruzi* and Host of a Putative Novel *Trypanosoma* Species." *Vector-Borne and Zoonotic Diseases*. 13:1:22-30. 8 Jan 2013.

[34] Kjos S, Snowden K, Craig T, Lewis B, Ronald N, Olson J. "Distribution and Characterization of Canine Chagas Disease In Texas." *Veterinary Parasitology.* 152:3-4:249-256. 15 Apr 2008.

[35] Kjos, Ibid.

area that were positive for *T. cruzi*, that the military working dogs were part of a domestic transmission cycle of *T. cruzi* in Texas.[36]

Specifically to investigate a domestic transmission cycle in Houston and *T. cruzi* presence in canines, a study was conducted to test previously collected sera samples from stray dogs housed in two shelters. A total of 822 samples were obtained and tested via Chagas Stat-Pak kit with about a 3% prevalence of *T. cruzi*.[37] It is important to note that the Chagas Stat-Pak has only been validated on human sera samples from Latin America. On these samples, the sensitivity is 98.5% and the specificity is 94.8%.[38] However, when validated for detection of *T. cruzi* antibodies in wildlife reservoirs, in this case wild raccoons, the sensitivity dropped to 66.7-80% and the specificity was 96.3%.[39] It is possible that the 3% seroprevalence among Houston's shelter dogs using the Stat-Pak may be a gross underestimate of the prevalence of *T. cruzi* in the stray dog population.

A domestic transmission cycle does exist in Texas as supported by evidence from both triatomines infected with *T. cruzi* parasite as well as infection of wild mammalian reservoirs and now canines. The prevalence in these mammalian reservoirs, especially domestic dogs that have never traveled outside of the Houston area, can serve as surveillance and representation of prevalence of a *T. cruzi* infection cycle. This has implications for the people living in the southern United States, which was thought to be

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[36] McPhatter CPT L, Roachell W, Mahmood F, Hoffman L, et al. "Vector Surveillance to Determine Species Composition and Occurrence of *Trypanosoma cruzi* Infection at Three Military Installations in San Antonio, Texas." *US Army Med Dept J.* Jul – Sept 2012. 12-21.

[37] O'Day, Sarah. "Seroprevalence of Chagas Disease in Texas Among Shelter Dogs in Houston and the Rio Grande Valley Region and Its Implication for Human Infection." Masters Thesis. *The University of Texas School of Public Health*. 2011. UMI 1494824

[38] Luquetti A, Ponce C, Ponce E, Esfandiari J, et al. "Chagas' Disease Diagnosis: A Multicentric Evaluation of Chagas Stat-Pak, a Rapid Immunochromatographic Assay With Recombinant Proteins of Trypanosoma cruzi". *Diagn Microbiol Infect Dis.* 46:4:265-271. Aug 2003.

[39] Yabsley M, Brown E, Roellig D. "Evaluation of the Chagas Stat-Pak Assay for Detection of Trypanosoma cruzi Antibodies in Wildlife Reservoirs." *Journal of Parasitology*. 95:3:775-777. Jun 2009.

a non-endemic country for Chagas disease as this cycle can be extrapolated to humans in the area with similar lengthy outdoor exposures.[40]

Human Chagas Disease in the United States

Compounded by the warm climate, excessive amount of time spent outdoors, and poorly created structures, Chagas disease may disproportionately afflict those living below the poverty line in the United States (reviewed in [41]). Often, many of these individuals are Hispanic immigrants in the southern counties of Texas bordering Mexico.[42] According to the US Census Bureau, 17.4% of persons in Texas are below the federal poverty level.[43] However, the poverty rates are not equally represented by race. Of those categorized as living in poverty, 16% are African American and 53% are Hispanic. Similarly, of the total population in Texas, about 24% of the African American population and 25% of the Hispanic population are living below the poverty line.[44] Poverty is highly correlated with other health factors, such as chronic diseases, but increasing in concern is the association between poverty and neglected tropical infections like Chagas disease in the United States.

Individuals often do not know they are infected until cardiac symptoms occur, so many individuals continue to participate in activities such as donating blood and organs necessitating the testing of the blood supply for *T. cruzi* antibodies. In 2007, the US

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[40] O'Day. 2011.

[41] Hotez P, Dumonteil E, Cravioto M, et al. "An Unfolding Tragedy of Chagas Disease in North America." *PLoS Neglected Tropical Diseases*. 7:10. Oct 2013.

[42] Hotez, Peter. "Tropical Diseases: The New Plague of Poverty." *The New York Times*. 18 Aug 2012. http://www.nytimes.com/2012/08/19/opinion/sunday/tropical-diseases-the-new-plague-of-poverty.html

[43] US Census Bureau. Texas State Facts. 6 Jan 2014.

[44] University of Texas at Austin. "Texas Politics". Liberal Arts Instructional Technology Services. 3rd Edition, Revision 102. 2014.

Department of Health and Human Services Food and Drug Administration (FDA) approved and implemented Biologics License Applications (BLAs) to test for *T. cruzi* antibodies in the whole blood and blood component supplies from donations (reviewed in [45]). *T. cruzi* parasite can be present in all blood products, including plasma and platelets (pers. comm. Dr. Juan Leon). Although whole blood produces a greater risk for transmission, platelets and plasma can transfer the parasite between individuals.[46] Previous discussion about testing for *T. cruzi* antibodies in the blood donor supply had begun in 1995, but at the time the FDA decided that the tests available were not adequate.[47] An FDA licensed enzyme-linked immunosorbent assay (ELISA) became available in December 2006 and all subsequent blood supplies since the end of January 2007 have been tested. However, this testing is not mandatory although most states participate in this testing recommendation. The radioimmunoprecipitation assay (RIPA) is often used as a confirmatory test. Repeat donors are only tested for *T. cruzi* antibodies during the first blood donation and qualify for donation in the future based on an initial negative Chagas disease status. The committee agreed that the risk of a newly acquired infection is not great enough to warrant additional testing for each blood donation and the additional money spent.[48] A study testing 2,940,491 donations (1,183,076 different donors) from January 2007 through December 2009 identified that the seroprevalence of *T. cruzi* antibodies among blood donations is 1 per 33,039 donations (1 per 13,292

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[45] HHS FDA. "Guidance for Industry: Use of Serologic Tests to Reduce the Risk of Transmission of Trypanosoma cruzi Infection in Whole Blood and Blood Components Intended for Transfusion." US Food and Drug Administration Center for Biologics Evaluation and Research. Dec 2010.
[46] Leon, Juan. Personal communication: email correspondence. Emory University. 23 Mar 2014.
[47] HHS, Ibid.
[48] HHS, Ibid.

donors).[49] However, only about 11% of individuals with positive *T. cruzi* infection detected through blood donation have contacted the CDC for access to treatment (reviewed in [50]).

Although there have only been seven documented cases of transfusion acquired *T. cruzi* infection, this may be an underrepresentation based on the number of blood donors who are unaware of their infection due to the paucity and generic nature of symptoms once a transfusion recipient has been infected. All seven documented cases occurred in individuals who were immunocompromised making their symptoms more apparent. One case occurred in an eleven-year-old girl with Hodgkin disease and had never traveled to an endemic area.[51] Similarly, another case in 2007 occurred when a three and a half year old girl who had Stage 4 neuroblastoma received multiple blood components.[52] Many other individuals infected through blood transfusions may go undetected.[53]

Human Chagas disease cases may be occurring in other vulnerable subpopulations, specifically in Houston, Texas (study site). Homeless individuals may be at high risk due to extended periods of time spent outdoors. As seen in domestic dogs with *T. cruzi* infection spending excessive time outdoors, homeless individuals may have this same exposure from time spent outdoors. Similarly, an additional risk factor for this population may be the increase in exposure to blood products that contain the *T. cruzi* parasite.

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[49] Custer B, Agapova M, Bruhn R, Musch M, et al. "Epidemiologic and Laboratory Findings From 3 Years of Testing United States Blood Donors for Trypanosoma cruzi." *Transfusion*. 52:1901-1911. Sept 2012.
[50] Stimpert K and Montgomery S. "Physician Awareness of Chagas Disease, USA." *Emerging Infectious Diseases*. 16:5:871-872. May 2010.
[51] Grant I, Gold J, Wittner M, Tanowitz H, et al. "Transfusion-Associated Acute Chagas Disease Acquired in the United States." *Annals of Internal Medicine*. 111:10:849-851. 15 Nov 1989.
[52] Young C, Losikoff P, Chawla A, Glasser L, Forman E. "Transfusion-Acquired Trypanosoma cruzi Infection." *Transfusion*. 47:3:540-544. Mar 2007
[53] Young C, Losikoff P, Chawla A, Glasser L, Forman E. "Transfusion-Acquired *Trypanosoma cruzi* Infection." *Transfusion*. 47:3:540-544. Mar 2007.

Homeless individuals often engage in high-risk behaviors such as injection drug use, unregulated tattoos, and donating and receiving plasma and other blood products. All of these factors may increase the risk of Chagas disease in the homeless population but much about this is still unknown.

Demographics of Homeless Population

Demographics of homeless populations are often hard to capture due to enumeration barriers such as lack of photo identification and dynamic nature of sleeping locations. Often, homeless individuals lack photo identification (ID) due to theft on the streets, loss, or damage. This precludes many individuals from accessing services that require proof of identification, such as some medical clinics. When trying to reapply for a photo ID, individuals are told a birth certificate is needed; however, a photo ID must be presented when applying for a new birth certificate.[54] This cycle is a barrier for individuals seeking shelter, trying to apply for a job, or apply for government benefits. Since individuals without a photo ID are often not registered in any database or system, this makes it difficult to capture the demographics of the homeless population.

To address these difficulties, each year the Coalition for the Homeless of Houston/Harris County in conjunction with the Continuum of Care, Houston Housing Authority, Harris County Housing Authority, Corporation for Supportive Housing, and many others, conducts a 'Registry Week' to capture specific names of individuals living on the streets or in shelters as well as group demographics of the homeless population of Houston, Texas. The most recent registry week conducted occurred between May 5 through 10,

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[54] Tompkins, Sara Simon. "Photo Identification Barriers Faced by Homeless Persons: The Impact of September 11". National Law Center on Homelessness and Poverty. Apr 2004.

2013. A total of more than 160 community volunteers canvassed the streets of Houston and surveyed a total of 963 homeless individuals.[55]

A majority of homeless individuals in Houston, Texas identified as African-American, non-Hispanic males. Of the 963 homeless individuals in Houston captured by this survey, 84% identified as male, 66% identified as African-American, and 89% identified as non-Hispanic. Chronic homelessness was defined as "having experienced four or more episodes of homelessness in a three year period or has been continuously homeless for a year or more."[56] Based on this definition, 59% of respondents were chronically homeless in Houston. Respondents were also categorized as 'vulnerable' or 'non-vulnerable' based on whether or not the individual had been homeless for more than six months. Once categorized as vulnerable, the participant was given a score on an index from 0 to 8 based on a variety of factors such as age, health status, and total length of time homeless. No individual has scored a vulnerability index of more than five. Of those categorized as non-vulnerable, the average amount of time homelessness is three years while those categorized as vulnerable had an average length of time homeless of five years.[57] From this survey, a majority of homeless individuals had long-term exposure outdoors based on their total length of homelessness.

Healthcare Access and Usage Among Homeless Population of Houston, Texas

Homeless individuals in the Houston homeless population often suffer from both acute and chronic diseases requiring medical attention. Based on the Registry Week data, 48%

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[55] Chapman Semple, Mandy. "100,000 Homes Houston: Registry Week Fact Sheet May 5-10, 2013." *Coalition for the Homeless of Houston/Harris County.* May 2013.
[56] Chapman Semple, Ibid.
[57] Chapman Semple, Ibid.

of homeless individuals suffer from chronic health conditions and 46% suffer from mental health conditions.[58] The estimates may be underreporting of these health issues because individuals may not have been diagnosed by a healthcare professional with chronic conditions such as diabetes or heart diseases because access to healthcare is a challenge. Similarly, individuals may not have been officially diagnosed with a mental health condition or have not chosen to recognize this diagnoses due to stigma or detachment from the truth. Nevertheless, both chronic diseases and mental health pathologies are prevalent in the homeless population of Houston. Not only in Houston, it has been identified that homelessness is associated with a higher burden of cardiovascular issues, a type of chronic pathology. It is necessary to understand the underlying causes of cardiac issues in the homeless population. In one study in Louisiana, where the triatomine is known to inhabit, cardiac issues were much higher in the homeless population than the non-homeless population; this could be explained by higher prevalence of smoking and hypertension, but cholesterol and diabetes were not significantly different in the two populations.[59,60] Although this study did not capture the Houston homeless population, the Louisiana homeless population may be analogous due to the similar climates and presence of the triatomine vector in both locations.

Because more than half of those interviewed (53%) in the Louisiana study reported having no health insurance, the Emergency Department (ED) was often the main source of healthcare, particularly for those with chronic illness, resulting in high costs incurred

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[58] Chapman Semple, Ibid.
[59] Jones, Charlotte et al. "Cardiovascular Disease Risk Among the Poor and Homeless- What We Know So Far." *Curr Cardiol Rev.* 5(1):69-77. Jan 2009.
[60] Szerlip, Molly and Harold Szerlip. "Identification of Cardiovascular Risk factors in Homeless Adults." *The American Journal of the Medical Sciences.* 324(5):243-246. 2002 Nov.

by the state. In Houston, among all respondents to the Registry Week survey, a total of 964 ED visits were reported in the past three months. Assuming an average of $762.23 per ED visit, this is a total of $2,939,158.88 in annual costs assumed by the state.[61] This survey found that ED usage among homeless individuals resulting in high costs for the states. This is applicable to other homeless populations in the southern United States because of the low insurance coverage among homeless populations as well as the presence of the triatomine increasing risk of Chagas related cardiomyopathy. Due to cardiac symptoms from Chagas disease, the homeless population may suffer disproportionately and utilize the emergency department more frequently raising costs for the state.

Risk Factors Among Homeless Populations

Many behavioral risk factors, in addition to long outdoor exposures, may increase the potential risk of Chagas disease among the homeless population in areas where triatomines and *T. cruzi* are present. Of those captured by the Registry Week survey in Harris County and Houston, 66% of respondents reported issues with alcohol and drugs. Injection drug use and sharing of needles is a common way to spread pathogens present in blood and blood products**,** such as HIV (reviewed in [62]). In a study conducted among middle-aged injection drug users in Houston, Texas, more than two-thirds of respondents (n = 452) reported being homeless in the past year. About 50% reported sharing injection equipment and 70% reported sharing drug preparation materials.[63] Similarly, according to

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[61] Chapman Semple, "100,000 Homes Houston: Registry Week Fact Sheet May 5-10, 2013." 2013.
[62] Noor S, Ross M, Lai D, Risser J. "Clustered Drug and Sexual HIV Risk Among A Sample of Middle-Aged Injection Drug Users, Houston, Texas." *AIDS Care*. 25:7:895-901. 2013.
[63] Noor, Ibid.

this study, "IDUs [injection drug users] who used a needle after someone else had injected with it in the past 12 months had higher odds of being homeless (OR = 2.64, 95% CI: 1.71-4.12)."[64] Homeless individuals are at an increased risk of participating in risky behaviors associated with transmitting blood-borne pathogens, and since *T. cruzi* can circulate in the blood, homeless individuals may also become infected with Chagas disease through injection drug use and needle sharing behaviors.

Unregulated tattoos in which individuals share needles, ink, or other equipment that have contact with blood may present another behavior that increases the risk of transmitting blood-borne pathogens.[65] Tattoos tend to be relatively common in homeless individuals, especially those who have spent time in the prison systems (reviewed in [66]). Hepatitis C Virus (HCV) is a pathogen often transmitted through contact with infected blood; in a study that excluded individuals with a previous history of injection drug use or blood transfusion, those with a history of one or more tattoos (n = 465) after adjustment for age, sex, and race/ethnicity had an odds of 5.17 (95% CI 3.75 – 7.11, $p < 0.001$) of being HCV positive.[67] Sharing of needles, either for injection drug use or unregulated tattoos, puts individuals at higher risk for transmitting pathogens circulating in blood. Often, homeless individuals participate in these behaviors more frequently than the general population putting this subpopulation at higher risk.

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[64] Noor, Ibid, pg. 898.

[65] Strehlow A, Robertson M, Zerger S, et al. "Hepatitis C Among Clients of Health Care for the Homeless Primary Care Clinics." *Journal Health Care Poor Underserved.* 23:2:811-833. May 2012.

[66] Strehlow, Ibid.

[67] Carney K, Dhalla S, Aytaman A, Tenner C, and Francois F. "Association of Tattooing and Hepatitis C Virus Infection: A Multicenter Case-Control Study." *Hepatology*. 57:6:2117-2123. Jun 2013.

Not only does use of alcohol and drugs lead to other potentially risky behaviors (reviewed in [68]), it is suspected that use of alcohol and drugs can incapacitate a person such that the individual will not be bothered by or protect themselves against insects and bugs that may cause diseases such as West Nile Virus, Typhus, or potentially Chagas disease.

Outdoor Exposures, Shelter Seeking Behaviors, and Risk Factors for Exposure to Vector-Borne Illness Among Homeless Populations

Although a majority of homeless individuals throughout the United States do not identify as female, there is a disproportionate amount of violence affecting females living on the streets, which influences shelter seeking behaviors. Many women experience violence, especially sexual violence, while living on the streets. This may cause females to seek safety in a shelter to sleep in at night, especially all-female shelters, in order to escape the violence experienced on the streets. (reviewed in [69]). In Houston, Texas during the 2013 Registry Week survey of homeless individuals, 32% of respondents reported being victims of a violent attack since becoming homeless.[70] Similarly, women often have an easier time qualifying for social services, especially with dependents and may receive an income check of some sort from the government (food assistance, etc.) sooner than men leading to a shorter time homeless (reviewed in [71]). It is likely that women also may have a lower risk of engaging in risky behaviors and acquiring vector-borne diseases due to

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[68] James S, McField E, Montgomery S. "Risk Factor Profiles Among Intravenous Drug Using Young Adults: A Latent Class Analysis (LCA) Approach." *Addictive Behaviors*. 38:3:1804-1811. Mar 2013.
[69] Jasinski, Jana et al. "The Experience of Violence in the Lives of Homeless Women: A Research Report." *U.S Department of Justice*. Doc Num 211976. 2005 Nov.
[70] Chapman Semple, "100,000 Homes Houston: Registry Week Fact Sheet May 5-10, 2013." 2013.
[71] Daly, Gerald. "The Experience of Homeless People." Homeless: Policies, Strategies, and Lives on the Street. Routledge, New York, NY. 1996. pg. 133

their increased participation in shelter-seeking behaviors. However, even though homeless females tend to seek indoor shelter more frequently than homeless males, any individual who sleeps outdoors or spends prolonged amount of time outdoors is at an increased risk of vector-borne diseases.

Homeless populations often suffer from heavy burdens of diseases transmitted by louse, flea, ticks, flies, and arthropods due to extended periods outdoors. The high incidences of diseases from these insects are associated with high poverty, poor sanitation, close quarters, and exposure to the elements (reviewed in [72,73]). As homeless individuals already carry a high burden of disease associated with insects, triatomines could potentially afflict this population due to the prolonged outdoor exposure from sleeping outdoors and lengthy periods of homelessness. A study to assess the seroprevalence of West Nile Virus (WNV) infection, which is transmitted by mosquitoes, among the homeless population was conducted in Houston, Texas. Mosquitoes transmit WNV, so individuals spending more time outside may be at higher risk. The study found that those who were homeless for longer than one year had a higher seroprevalence than those with stable housing (16.4% prevalence for homeless > 1 year; 4.7% prevalence for those with stable housing). Additionally, the odds of being WNV positive among those homeless for longer than one year are 3.2 times the odds of being WNV positive among those who identified as having stable housing (95% CI 1.3 – 7.7, p=0.01).[74] Similarly, typhus is

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[72] Bonilla D, Kabeya H, Kosoy M, et al. "*Bartonella Quintana* in Body Lice and Head Lice From Homeless Persons, San Francisco, California, USA." *Emerging Infectious Diseases*. 15:6:912- 915. Jun 2009.

[73]Brouqui, Philippe. "Arthropod-Borne Diseases Associated With Political and Social Disorder." *Annual Review of Entomology*. 56:357-374. 2011.

[74] Meyer T, Bull L, Murray K, et al. "West Nile Virus Infection Among the Homeless, Houston, Texas." *Emerging Infectious Diseases*. 13:10:1500-1503. Oct 2007.

another disease that is transmitted by fleas or lice and puts homeless individuals at higher risk. Among a total of 176 samples tested from homeless individuals in Houston, Texas, 10.7% were reactive to typhus group rickettsiae antigens by enzyme-linked immunosorbent assay (ELISA) and immunofluorescence (IFA). About half of those who tested positive reported mostly living on the streets or in emergency shelters, and 35% reported spending all day and all night outdoors.[75] Homeless individuals spending time outdoors have an increased exposure to insects that cause disease, such as ticks, fleas, and mosquitos, particularly in areas where these insects are present such as Houston, Texas. This logic can potentially be applied to the triatomine that carries *T. cruzi* parasite because it is found in Houston, Texas and can come in contact with individuals spending prolonged periods of time outdoors.

There is a clear need to investigate the risk of Chagas disease among Houston's homeless population. Much is still unknown about Chagas disease in the United States, but this subpopulation spends a significant amount of time outdoors where the triatomine vector is present and often engages in risk behaviors for spreading blood-borne pathogens, such as sharing needles from injection drug use and tattoos requiring more attention and research. This study aims to address this need and add to the knowledge about Chagas disease in the homeless population of Houston, Texas.

Significance

This research quantifying the risk of Chagas disease among Houston's homeless population can be the foundation for future research. Knowing that a risk exists will help

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[75] Reeves W, Murray K, Meyer T, et al. "Serological Evidence of Typhus Group Rickettsia in a Homeless Population in Houston, Texas." *Journal of Vector Ecology*. 33:1:205- 207. Apr 2008.

to inform future studies investigating environmental distribution of triatomines infected with *T. cruzi* and seroprevalence of *T. cruzi* antibodies in homeless individuals. This work may lead to recommendations for education targeted at homeless populations and emergency department clinicians. To implement this educational program directed at reducing risk behaviors like sharing needles and sleeping outdoors as well as clinical signs and symptoms, it is our hope to partner with key stakeholders already working with this population. Houston Police Department Homeless Outreach Team and SEARCH Homeless Services work directly with homeless populations and can help to disseminate this information. Similarly, the Special Assistant to the Mayor for Homeless Initiatives in Houston already has an agenda to address health and social needs of homeless populations, and education about Chagas disease falls within this realm. By achieving this goal of quantifying the risk of Chagas disease among the homeless population of Houston, there will hopefully be immediate benefits in forms of education to homeless individuals and emergency department clinicians.

INTRODUCTION

There is a clear need to understand the risk of Chagas disease here in the United States. *Trypanosoma cruzi* infected vectors inhabit the southern United States,[76] vulnerable populations associated with poverty also live in these areas and may come in contact with the vector outdoors,[77] and subpopulations often engage in risky behaviors[78] associated with transmission of pathogens through infected blood, such as *T. cruzi.* More attention is needed to investigate the risk of vulnerable groups, such as homeless populations and Hispanic immigrants. Attention to Chagas disease in the United States is necessary because of the financial strain it will put on health systems due to Chagas cardiomyopathy exhibited by some patients and the new emerging risk of domestically acquired cases among vulnerable populations that engage in risky behaviors.

Caryn Bern and Susan Montgomery of the CDC have projected that there are a total of 300,167 *T. cruzi* infected individuals in the United States. Infected individuals, mostly immigrants from Latin American countries, live all across the United States.[79] Not only are individuals arriving in the United States already infected with *T. cruzi*, but also infected triatomine vectors are present throughout the southern United States opening up the possibility of domestically acquired cases. For example, focusing in Texas, a study that pooled together triatomine specimens, both preserved and newly collected, identified

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[76] Bern, Caryn et al. "*Trypanosoma* cruzi and Chagas' Disease in the United States." Clinical Microbiology Reviews. 24:4:655-681. Oct 2011

[77] University of Texas at Austin. "Texas Politics". Liberal Arts Instructional Technology Services. 3rd Edition, Revision 102. 2014.

[78] Noor S, Ross M, Lai D, Risser J. "Clustered Drug and Sexual HIV Risk Among A Sample of Middle-Aged Injection Drug Users, Houston, Texas." *AIDS Care*. 25:7:895-901. 2013.

[79] Bern C, Montgomery S. "An Estimate of the Burden of Chagas Disease in the United States." *Clinical Infectious Diseases*. 49:5. Sept 2009.

that triatomines inhabited 38% of counties in Texas (97 of 254 counties) and infected triatomines inhabited 19% of counties (48 counties). 241 specimens were newly collected, and 51% of these were infected with *T. cruzi*. Almost all of the infected triatomines were collected inside or near houses putting humans at risk for *T. cruzi* infection in Texas.[80] Homeless individuals may be at high risk due to extended periods of time spent outdoors in areas where the triatomine vector is present. Additionally, there has been an increase in homelessness in many southern states where the triatomine is also present.[81] More individuals in the southern United States may be exposed to *T. cruzi* infected triatomines.

Only seven autochthonous human cases via the triatomine vector have been diagnosed and documented in the United States, specifically four cases in Texas and one case each in California, Tennessee, and Louisiana.[82] None of the individuals had any history of travel to endemic locations. These are the only cases documented as acquired in the United States since 1955, indicating that this may be an underreporting of cases domestically acquired due to lack of diagnosis. It is possible that in addition to these identified case many undiagnosed infections exist, especially among vulnerable populations not seeking or receiving health care.

High-risk groups, such as Latin American immigrants and homeless populations, could potentially be at high risk for Chagas disease. However, the homeless population is often a subpopulation overlooked and understudied. It is known that homeless populations

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[80] Kjos S, Snowden K, Olson J. "Biogeography and *Trypanosoma cruzi* Infection Prevalence of Chagas Disease Vectors in Texas, USA." *Vector-Borne and Zoonotic Diseases*. 9:1:41-49. 2009.

[81] Homelessness Research Institute, National alliance to End Homelessness. *The State of Homelessness in American 2013*. 2013.

[82] Bern. "Trypanosoma cruzi and Chagas' Disease in the United States." 2011.

often suffer from heavy burdens of diseases transmitted by louse, flea, ticks, flies, and arthropods due to extended periods outdoors. The high incidences of diseases from these insects are associated with high poverty, poor sanitation, close quarters, and exposure to the elements (reviewed in [83,84]). Based on this information, triatomines and *T. cruzi* infection could potentially afflict this population due to the prolonged outdoor exposure from sleeping outdoors and lengthy periods of homelessness.

To address these needs, the goal of this study was to investigate the risk of Chagas disease among Houston's homeless population participating in previously identified high-risk behaviors and quantify knowledge through questionnaires. An ideal study site in the United States was Houston, Texas as it was a city that combined multiple characteristics to understand the risk of Chagas disease among the homeless population. Houston has both a sizeable homeless population and the *T. cruzi* infected triatomine vector. What we find in Houston, Texas has applicability to homeless populations in other southern cities and states where the triatomine vector is present. This study will help to understand the risk of homeless populations to Chagas disease in the United States and provide the foundation for future research.

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[83] Bonilla D, Kabeya H, Kosoy M, et al. "*Bartonella Quintana* in Body Lice and Head Lice From Homeless Persons, San Francisco, California, USA." *Emerging Infectious Diseases*. 15:6:912- 915. Jun 2009.

[84]Brouqui, Philippe. "Arthropod-Borne Diseases Associated With Political and Social Disorder." *Annual Review of Entomology*. 56:357-374. 2011.

METHODS

Target Population and Consent

This study was aimed at the homeless population of the Houston metropolitan area. A total of 212 homeless individuals in the Houston area were selected to participate through an encounter sample gathered between June and August 2013. The sample size was calculated based on the estimated prevalence of Chagas diseases in the homeless population of Houston, Texas. Sample size is based on the assumption of prevalence from an unpublished studying finding a 14.4% prevalence, an estimated homeless population of 8,538 based on the annual homelessness census by the Coalition for the Homeless, and a 5% precision. A waiver of written consent was granted from the Emory IRB, such that participants were read an oral consent script, asked if it was fully understood, repeated back main points, and were then asked to provide informed consent. This study, IRB00066083, was reviewed by the Institutional Review Board (IRB) of Emory University and determined to be exempt under 45 CFR 46.101(b)(2).

To administer the survey, participants were identified through help from the Houston Police Department HOT Team (Homeless Outreach Team) and SEARCH Homeless Services Mobile Outreach Team. The survey information was documented completely anonymously, and participation was voluntary. Refusal to participate did not impact the services provided by either of these partnering groups. If included, participants were not compensated directly for their participation.

Inclusion and Exclusion Criteria

Inclusion in the study included individuals who self-identified as 18 years or older and younger than 89 years old and were excluded outside of this age range. Participants were not excluded based on gender, ethnicity, or other characteristics. Individuals meeting the definition of 'currently homeless' were included in the survey sample. For this survey, the definition of 'currently homeless' included any individual living and sleeping outdoors or in an emergency shelter. Individuals were excluded from participation if the individual had a permanent address, a room in another person's home, or living in veterans' single room occupancy apartments. As the informed consent and survey were administered in English, only individuals able to fluently communicate in English were included. Lastly, individuals that were unable to give informed consent due to mental illness or substance abuse were not included in the study.

Study Instrument

In order to assess the risk of Chagas disease among the homeless population of Houston, Texas, a quantitative survey instrument was created and used to collect data. Survey was developed through literature identification of proper survey methods among homeless populations and common high-risk behaviors in this group. The main high risk behaviors identified were injection drug use and sharing of needles, unregulated tattoos and sharing of tattoo equipment, prolonged outdoor exposure and number of nights outdoors per week, and blood transfusion before 2007. Five modules were included in the survey: demographic information, health history, knowledge about Chagas disease, travel history, and daily activities and behaviors. The study instrument was revised based upon input from professional groups working within the homeless population and from a small pilot

sample. The survey was implemented among a few homeless individuals to receive feedback about the ease of the survey. Overwhelming feedback stated the survey was too long. Based on this feedback, the survey was condensed such that it could be completed in 10 minutes instead of 30 minutes. Questions were coded based on the response, and most questions were dichotomous Yes-No answers. Each question included choices for 'Don't Know' and 'Refuse to Answer', and these answers were coded consistently throughout all questions. Answers within each question were given a unique code and documented in a codebook in order to maintain uniformity throughout the database. Surveys were administered face-to-face, verbally, anonymously, and consent was documented on paper copies of the survey. The survey was designed to be administered in less than ten minutes.

Data Management and Analysis

Data collected from the surveys were input into a Microsoft Excel (2011) database organized by participant ID number. The surveyor manually entered data from each survey into a database and repeated this practice in a second database at the end of every week. All discrepancies between the two databases were documented and compared to the original paper copies of the survey before analysis. Discrepancies found between the two databases were documented in a spreadsheet with incorrect data identified, correct information from the paper copy of the survey, the change made, database where change was made, and the date of the change. After all 212 surveys were input into the database, a 5% comparison was conducted against the original paper copies. A random sample of the database was pulled, a new database was created with information directly from the

paper copies, and then a comparison was conducted between the original database and the new input to check for inconsistencies. No inconsistencies were found.

Data analysis was completed in SAS (Version 9.3). Continuous variables age, total length of time homeless, number of nights outdoors in the past week, and average number of nights slept outdoors per week were assessed for normality and considered non-parametric; therefore, the median was the best descriptive statistic for these variables. To determine if there was a difference between risk of Chagas disease among men and women, Chi square tests were conducted when appropriate (if expected cell count was less than five, Fisher's Exact Test was used). To determine a difference between males and females with continuous, non-parametric variables, a Mann-Whitney-Wilcoxon test was performed. Variables for epidemiological models were based on biological plausibility and assessed for multicollinearity. Logistic regression models were performed via backward selection with an alpha of 0.10 and a significant p-value of 0.05.

RESULTS

A total of 212 homeless individuals were surveyed in Houston, Texas, and more than three-fourths identified as male and about a quarter self-identified as Hispanic (Table 1). Nearly all were born in the United States, and most respondents identified as either African American (43%) or Caucasian (41%). About half of surveyed respondents had health insurance, and of those with insurance, about two-thirds had a Harris County Gold Card as the type of health coverage (Table 2). For those with and without health insurance, about three-fourths (74%) used the Emergency Room as their primary source of healthcare. Only 17% (36) had a diagnosed health conditions, but about 27% (58) experienced chest pains in the past twelve months (Table 2). In summary, a majority of those surveyed were male, African-American, American-born individuals using the Emergency Department as their primary source of healthcare.

We assessed knowledge about Chagas disease among the homeless population in the second module of the survey. Only 7 individuals had ever heard of Chagas disease (Table 3). Those having heard of Chagas disease had previous involvement in the medical community such as a lab technician or had emigrated from an endemic country. Although many had not heard of Chagas disease, about 30% of respondents recognized a picture of the triatomine, and 5 individuals believed they had been bitten by the triatomine. About 10% of respondents were unsure if they had been bitten (Table 3). The percentages of respondents who had heard of Chagas disease, recognized the triatomine picture, or believed to have ever been bitten was similar between males and females. In conclusion, a majority of individuals had never heard of Chagas disease but were fairly confident in recognizing the triatomine in the Houston area when shown a picture**.**

We asked respondents about certain risk behaviors, such as injection drug use and unregulated tattoos. As seen in Table 4, about 28% (60) of respondents had ever used needles to inject drugs, and about half of these individuals had shared needles. Males were compared with females because previous studies have found differences in risky behaviors. About 44% of all respondents received unregulated tattoos (not in a licensed shop), and 5 individuals recalled sharing tattoo equipment such as needles or ink in the process. In summary, more than a quarter of respondents identified engaging in risk behaviors, including unregulated tattoos and using needles to inject drugs.

The median total length of time homeless was different for males and females surveyed. The median total time homeless for male respondents was 104 weeks (2 years) and for female respondents was 76 weeks (1.5 years). The range of total time homeless for all respondents was between 2 weeks and 1300 weeks (25 years) (Figure 1). We asked respondents how many nights in the past week were spent sleeping outdoors as well as the average number of nights typically spent outdoors per week. The number of nights slept outdoors in the past week is significantly different between males and females sampled ($p = 0.022$) but not significantly different for the average number of nights slept outdoors per week (Figure 2). The average number of nights slept outdoors in the past seven nights of the survey was about five for males and about three nights for females.

To assess whether an association exists between risk factors and knowledge of Chagas disease, three epidemiological models were created. The first model, as seen in Table 5, was to assess an association between those believing to have been bitten by a triatomine and demographic and health factors. Sex, Hispanic identification, race, diagnosed heart condition, and total time homeless were all not significant in the model but forced into

the model due to biological significance. Having chest pain in the past year was a significant predictor; those who did not have chest pain were 32 times more likely to believe to have been bitten by the triatomine than those with chest pain.

A second model, as seen in Table 6, was created to assess an association between recognition of the triatomine picture with demographic characteristics and sleeping behaviors. None of the predictors were statistically significant; however, sex, Hispanic identification, race, total time homeless, and average nights outdoors per week were forced into the model due to biological significance.

Lastly, a model was created to assess associations with total length of time homeless. No predictors were statistically significant, but sex, Hispanic ethnicity, race, injection drug use, unregulated tattoo, and blood transfusion variables were forced into the model due to biological significance. There were no significant predictors associated with total length homeless, but males who inject drugs had a longer total time homeless.

DISCUSSION

The goal of this research is to assess the risk of Chagas disease among Houston's homeless population by participation in previously identified high-risk behaviors among this population. The study identified that the median total time homeless for males and females differed significantly; the medial total time homeless for male respondents was 104 weeks (2 years) and 76 weeks (1.5 years) for female respondents. Second, the research also identified that nearly three-fourths of homeless individuals used the Emergency Department as their primary location of healthcare services. Cardiac issues are typical of symptomatic Chagas disease, and although only 17% had a diagnosed heart condition, about 27% experienced chest pains in the past twelve months. Third, the research found that five respondents affirmatively believed they had been bitten by the triatomine and another twenty respondents were unsure if a bite received was from the triatomine.

First, we found that the median total time homeless for males and females differed significantly; the medial total time homeless for male respondents was 104 weeks (2 years) and 76 weeks (1.5 years) for female respondents. We hypothesize that females may have a significantly shorter total time homeless than men because many women experience violence, especially sexual violence, while living on the streets.[85] This may cause females to seek safety in a shelter to sleep in at night, especially all-female shelters, in order to escape the violence experienced on the streets. One study found that, "women with violent experiences during the past year were more likely than those without these

[85] Jasinski, Jana et al. "The Experience of Violence in the Lives of Homeless Women: A Research Report." *U.S Department of Justice*. Doc Num 211976. 2005 Nov.

experiences to have spent time living on the streets during the past 60 days."[86] Similarly, a second hypothesis as to why females had a significantly shorter total time homeless than males is that females often have an easier time qualifying for social services, especially with dependents and may receive an income check of some sort from the government (welfare, etc.) sooner than men.[87] As evidenced in Calsyn and Morse's study among homeless individuals in St. Louis, homeless males were less likely than homeless females to receive government assistance in the form of medical treatment, welfare, food stamps, public federal housing, and local agency housing assistance.[88] Additionally, in a national study of homeless individuals conducted by Healthcare for the Homeless Clinician's Network, only 38% percent of homeless males received government benefits as compared to 60% of homeless females.[89] In conclusion, it is likely that women may have a lower risk of Chagas disease due to homelessness and sleeping outdoors because women have a statistically shorter total length of time homeless as compared to male respondents in this study. This may decrease their exposure to the triatomine as the primary time and location for exposure is sleeping outdoors at night.

The second research finding identified that nearly three-fourths of homeless individuals used the Emergency Department as their primary location of healthcare services and about a quarter experienced chest pains in the past twelve months. One hypothesis to support the finding that most homeless individuals use the Emergency Department is that

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[86] Wenzel, Suzanne et al. "Risk Factors for Major Violence Among Homeless Women." *Journal of Interpersonal Violence*. 16(8):739-752. Aug 2001.
[87] Daly, Gerald. "The Experience of Homeless People." Homeless: Policies, Strategies, and Lives on the Street. Routledge, New York, NY. 1996. pg. 133
[88] Calsyn R, Morse G. "Homeless Men and Women: Commonalities and a Service Gender Gap." *American Journal of Community Psychology.* 18:4:597-608. 1990.
[89] O'Sullivan A, Caughlan J, Cunningham Roberts L, et al. "Single Males: The Homeless Majority." *Health Hands*: Healthcare for the Homeless Clinicians' Network. 5:3:1-6. Jun 2001.

most homeless individuals are uninsured or underinsured. One mechanism to explain this is the type of insurance most homeless individuals have, if any insurance at all. In a large study including 963 homeless individuals during the Harris County Registry Week, 447 participants (53%) did not have health insurance. As found in this study, 124 individuals (59%) had health insurance. However, three-fourths of these individuals had a Harris County Gold Card (Table 2). The Harris County Gold Card is a Texas public health benefit that provides subsidized medical costs; however, in order to enroll, an individual must provide photo identification. Many homeless individuals do not have photo IDs as these are often lost or stolen.[90] Only a small network of providers accepts this plan, long waits are common, medical services are only provided when deemed medically necessary, and only two public hospitals will cover costs for the Gold Card.[91] Another mechanism to explain this is that as access to healthcare is very much limited with the Harris County Gold Card, Emergency Departments may become the primary site for healthcare among the homeless population of Houston. A second hypothesis to describe the high rate of Emergency Department use as the primary source of healthcare is that most homeless individuals do not receive preventative or continuous care and often need immediate medical attention. Excluding obesity and stroke, homeless individuals are more likely to suffer from chronic illness like HIV, diabetes, and heart conditions than the general public. A mechanism to account for this is that complications can arise from disruption of care caused by inadequate housing and inability to pay or access care. Because of this, homeless individuals often do not manage their chronic conditions and

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[90] Tompkins, Sara Simon. "Photo Identification Barriers Faced by Homeless Persons: The Impact of September 11". National Law Center on Homelessness and Poverty. Apr 2004.
[91] Harris Health System. "Patient Eligibility." Access Care. 2014.

require immediate attention often sought in Emergency Departments (reviewed in [92]). A third hypothesis for both Emergency Department utilization and the observation that a quarter of individuals experiencing chest pains in the past twelve months is that homeless individuals suffer a disproportionate burden of cardiac issues as compared to the general adult population. Although only 17% of respondents had a diagnosed heart condition, about 27% experienced chest pains in the past twelve months (Table 2). As evidenced from a previously conducted masters thesis study, among deaths of the homeless population with a determined cause in Houston (Harris County), about 13% died due to cardiovascular causes.[93] It has been identified that homelessness is associated with a higher burden of cardiovascular issues (reviewed in [94]). Additionally, another mechanism to support the hypothesis that the homeless population suffers a high burden of cardiovascular disease is a study in Louisiana that observed cardiac issues were much higher in the homeless population than the non-homeless population. This could be explained by higher prevalence of smoking and hypertension, but cholesterol and diabetes were not significantly different in the two populations.[95,96] Cardiac issues are typical symptoms of chronic Chagas disease; this could be an important risk factor of cardiac symptoms among the homeless population, especially in areas where the triatomine is known to inhabit, and contribute to the overall burden since the significant difference cannot be explained by cholesterol or diabetes.

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[92] Sadowski L, Kee R, VanderWeele T, et al. "Effect of a Housing and Case Management Programs on Emergency Department Visits and Hospitalizations Among Chronically Ill Homeless Adults: A Randomized Trial." *JAMA*. 301:17:1771-1778. May 2009.
[93] [Unpublished thesis] Staggs, Sara MSW. "Homeless Mortality in Harris County in 2008." Thesis, The University of Texas School of Public Health, 2009.
[94] Jones, Charlotte et al. "Cardiovascular Disease Risk Among the Poor and Homeless- What We Know So Far." *Curr Cardiol Rev.* 5(1):69-77. Jan 2009.
[95] Jones, 2009. Ibid.
[96] Szerlip, Molly and Harold Szerlip. "Identification of Cardiovascular Risk factors in Homeless Adults." *The American Journal of the Medical Sciences.* 324(5):243-246. 2002 Nov.

A third research finding is that five respondents affirmatively believed they had been bitten by the triatomine and another twenty respondents were unsure if a bite received was from the triatomine. One hypothesis to describe why respondents had thought they had been bitten by the triatomine is the relatively long total time homeless and the majority of nights per week spent sleeping outdoors by respondents. The median total length of time homeless among all respondents was 104 weeks (2 years). Similarly, the average number of nights spent sleeping outdoors for individuals was five nights per week. Spending more time outdoors, especially at night, may increase the likelihood that an individual thought they had encountered and been bitten by the triatomine. Within this group, another observation to note, is that males had a significantly longer total time homeless and spent more nights sleeping outdoors per week as compared to females (Figure 1 and 2). As described above, this may be due to females seeking shelter more than males. Women tend to seek refuge in an emergency shelter more often than men due to the disproportionate amount of violence faced while sleeping on the streets.[97] Since the median total time homeless is two years, this may contribute to the number of individuals who believed they had been bitten by the triatomine or were unsure. A second hypothesis to account for the individuals who believed they had been bitten by the triatomine is the greater exposure to vectors that the homeless population experiences. Homeless populations are exposed to a number of vectors that may transmit disease and fall victim to a heavy burden of diseases transmitted by louse, fleas, ticks, flies, and arthropods.[98,99]

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[97] Jasinski J, Wesely J, Wright J, Mustaine E. Hard Lives, Mean Streets: Violence in the Lives of Homeless Women. Boston: Northeastern University Press, 2010.

[98] Bonilla D, Kabeya H, Kosoy M, et al. "*Bartonella Quintana* in Body Lice and Head Lice From Homeless Persons, San Francisco, California, USA." *Emerging Infectious Diseases*. 15:6:912- 915. Jun 2009.

[99] Brouqui, Philippe. "Arthropod-Borne Diseases Associated With Political and Social Disorder." *Annual Review of Entomology*. 56:357-374. 2011.

The high incidence of diseases from these insects are associated with high poverty, poor sanitation, close quarters, and exposure to the elements. A study to assess the seroprevalence of West Nile Virus (WNV) infection, which is transmitted by mosquitoes, among the homeless population was conducted in Houston, Texas. Mosquitos transmit WNV, so individuals spending more time outside may be at higher risk. The study found that those who were homeless for longer than one year had a higher seroprevalence than those with stable housing (16.4% for homeless > 1 year; 4.7% for those with stable housing). Additionally, the odds of being WNV positive among those homeless for longer than one year are 3.2 times the odds of being WNV positive among those who identified as having stable housing (95% CI 1.3 – 7.7, p=0.01).[100] Similarly, typhus is another disease that is transmitted by fleas or lice and puts homeless individuals at higher risk. Among a total of 176 samples tested from homeless individuals in Houston, Texas, 10.7% were reactive to typhus group rickettsiae antigens by enzyme-linked immunosorbent assay (ELISA) and immunofluorescence (IFA). About half of those who tested positive reported mostly living on the streets or in emergency shelters, and 35% reported spending all day and all night outdoors.[101] These wooded areas, parks, and wooden benches are common areas for homeless individuals to congregate and sleep during the night and are common areas for vectors. Conversations with experts who are part of the Houston Police Department's Homeless Outreach Team and independent homeless outreach organizations identified that, anecdotally through their work, that drug and alcohol abuse confounded the risk of exposure to bugs because individuals who are

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[100] Meyer T, Bull L, Murray K, et al. "West Nile Virus Infection Among the Homeless, Houston, Texas." *Emerging Infectious Diseases*. 13:10:1500-1503. Oct 2007.

[101] Reeves W, Murray K, Meyer T, et al. "Serological Evidence of Typhus Group Rickettsia in a Homeless Population in Houston, Texas." *Journal of Vector Ecology*. 33:1:205- 207. Apr 2008.

incapacitated and sleeping outdoors are less likely to realize that bugs are biting them while sleeping. These individuals are more likely to complain of chigger bites, bed bugs, mosquitoes, etc. By this logic, the same could be applied to triatomines; males are more likely to sleep outdoors and may be incapacitated by drugs or alcohol, so these individuals may be less likely to protect themselves against bites from bugs, including the triatomine. Any homeless individual spending a majority of nights per week sleeping outdoors and has a long total length of time homeless may have an increased amount of contact time with the triatomine and believe they had been bitten.

Limitations of this study include the non-random or systematic recruitment of respondents to participate in the survey. Individuals were approached and asked to participate when encountered by the SEARCH Homeless Services Outreach Team or Houston Police Department Homeless Outreach Team and researcher. These individuals were mostly encountered in encampments, near highway underpasses, in parks, or at a facility offering day services such as laundry, meals, and employment training. Those who seek day services may be systematically different than those who do not in regards to health status, mobility levels, education, etc. Similarly, respondents were more likely to decline participation when approaches during rush hour times, such as the morning or evening commutes, because this was often time for panhandling and peak of income generation. Those individuals who were able to panhandle and had been on the streets longer may systematically differ from those who chose to participate. Unfortunately, no incentives were given for participation except for cold waters that were given to all who were approached; those who participated may have been more willing to provide their time and answers than others.

Despite the limitations for data collection, certain strengths such as the short length of the survey, about 10 minutes, may have captured individuals who would not have otherwise been willing to participate in the survey. The data collection was completely anonymous and confidential, even in the presence of the Houston Police Department Homeless Outreach Team who helped to recruit participants, which may have encouraged individuals to participate, especially those engaging in risk behaviors such as injection drug use, who otherwise would not have considered participating. The anonymity may have also positively affected the accuracy of answers provided by respondents.

Based on these findings, the homeless population could be at higher risk for Chagas disease in the Houston area based on the length of time homeless and nights sleeping outside as well as high-risk behaviors for spreading pathogens in the blood such as injection drug use and unregulated tattoos. This information could inform future research as well as educational programming about Chagas disease aimed at both the homeless population and healthcare providers. Shelters should be providing education for homeless individuals to reduce their risk-behaviors related to Chagas disease. Just as the knowledge of West Nile increased rapidly among the homeless population of Houston following an educational campaign, the same approach should occur with Chagas disease. It is essential for the homeless population to understand how one can become infected, either through the bite of the triatomine or the sharing of blood products by needles.

This study supported the finding that the majority of homeless individuals utilize the emergency department as their primary healthcare site, specifically in Houston, Texas where the triatomine and potentially Chagas disease are present. Since this is usually the

first, and sometimes only, point of contact with medical providers, it is essential that emergency department medical providers are aware of the increased risk of Chagas disease among homeless populations. Providers should increase their knowledge about clinical symptoms and diagnosis for Chagas disease as it may often be overlooked or misdiagnosed, especially among the homeless population. Lastly, this study provides important information to suggest that further research be performed to assess the prevalence of Chagas disease among the homeless population of Houston, Texas and increase the knowledge of physicians, especially in Emergency Departments, about Chagas disease.

PUBLIC HEALTH IMPLICATIONS

Often, the general public does not know how Chagas disease is transmitted, and more focus is needed on education about transmission and clinical symptoms among medical providers, high-risk groups, and those working directly with these populations. High-risk individuals, such as immigrants from endemic countries, individuals engaging in behaviors that cause contact with other people's blood products (e.g.: injection drug users), and individuals who spend extended periods of time outdoors, must be educated on how to reduce their risky behaviors and how to identify the vector to help reduce their risk. Education surrounding other diseases such as West Nile has skyrocketed within the past few years, and the knowledge about Chagas disease must reach this level.

As the median homeless time for homeless males was two years and for homeless was one and a half years, steps must be taken to limit the contact homeless individuals have with the triatomine. About half of injection drug users stated having shared needles, so information needs to be disseminated about reducing risky behaviors for transmitting *T. cruzi* infection among other homeless individuals.

- Provision of tents or barriers for homeless individuals who cannot or will not seek shelter indoors at night to reduce risk of infection with *T. cruzi* from triatomine.
- Education among homeless individuals about the risk of infection with *T. cruzi* from risky behaviors such as sharing needles for injection drug use or unregulated tattoos may help to reduce the risk of Chagas disease among this population.

- An increase in awareness of where the vector lives and recognition of its characteristics may help decrease interactions between homeless individuals and the triatomine vector.
- More encouragement towards seeking shelter at night would also help to reduce the risk of exposure to triatomines and *T. cruzi* infection.

As many individuals identified the emergency room as their primary health care site, emergency room physicians need to be reminded of Chagas disease and the possibility of this diagnosis in high-risk populations.

- Educate physicians about clinical symptoms of Chagas disease and risk factors, such as homelessness, to increase testing and diagnosis. If a physician sees a homeless individual in the emergency department with dilated cardiomyopathy or a right-bundle branch block characteristic of Chagas disease, it is important to ensure that physicians can recognize the symptoms and risk factors to provide an accurate diagnosis.

Lastly, as many individuals seek services at shelters or organizations, directors and employees must be educated about Chagas disease so this information can be disseminated effectively.

- Shelters and homeless outreach organization employees also need to be educated about Chagas disease and risk factors to inform their clients.

- Pamphlets, brochures, and seminars are all possible ways to educate shelter employees as well as individuals utilizing the shelter and its services.

Lastly, more research is needed to improve screening and diagnostic tools, to understand environmental factors, and to identify the true burden. A transmission cycle has been established in Houston, but it is not yet known how homeless individuals are part of this cycle and the true burden of Chagas disease in this population. This survey identified that this population is truly at higher risk and vulnerable to Chagas disease in the Houston area.

- Diagnostic tools need strengthening and more research to identify sensitivity and specificity between tests and between strains that vary by geography. Since Chagas disease in the United States may be of a different strain and not much information is known, diagnostic tests should be developed to specifically detect strains acquired domestically in the United States.
- There is a need for more information regarding the triatomine and its behaviors in the United States. More environmental studies would help to locate exact areas of high triatomine presence as well as feeding and defecation behaviors that may distinguish species in the United States from species found in Latin America.
- Lastly, a study should be conducted to establish a prevalence of *T. cruzi* infection in homeless individuals in Houston and other major cities with both the triatomine vector and large homeless populations. This will help to inform next steps in both research and interventions.

TABLES AND FIGURES

Table 1. Demographics of Surveyed Homeless Individuals in Houston, TX 2013 (N =212).

Variable[1]	No. (%)
Male Sex	168 (79.0)
Hispanic	25 (12.0)
Race	
African American	92 (43.4)
Caucasian	87 (41.0)
Other	20 (9.4)
Mixed	7 (3.3)
American Indian	6 (2.8)
Asian	0 (0.0)
Was Born in United States	204 (96.2)

[1] Variables with one category are dichotomous. All who did not identify with one category identified with the other (i.e.: Male/Female, Yes/No).

Table 2. Health Characteristics of Surveyed Homeless Individuals in Houston, TX 2013 (N=212).

Variables[1]	No. (%)
Has Health Insurance[2]	124 (58.5)
Insurance Type[3]	
Harris County Gold Card	75 (61.5)
Medicaid	20 (16.4)
Medicare	10 (8.2)
Veteran's Benefits	9 (7.4)
Other	8 (6.6)
Healthcare Site	
Emergency Room	157 (74.1)
Clinic	35 (16.5)
Doesn't Seek Healthcare	11 (5.2)
Private Physician	8 (3.8)
Pharmacy	1 (0.5)
Has Diagnosed Heart Condition	36 (17.0)
Had Chest Pains in Past 12 Months	58 (27.4)

[1] Variables with one category are dichotomous. All who did not identify with one category identified with the other (i.e.: Male/Female, Yes/No).
[2] Two individuals answered 'Don't Know' about their health insurance status.
[3] Includes 122 of the 124 individuals indicating having health insurance. Two individuals did not indicate the type of insurance.

Table 3. Knowledge About Chagas Disease Among Homeless Individuals in Houston, TX 2013 (N = 212).

Variable^+	YES no. (%)	NO no. (%)	Don't Know	P-value
Heard of Chagas Diseases	7 (3.3)	203 (95.8)	2 (0.9)	
Males	5 (3.0)	161 (95.8)	2 (1.2)	0.773
Females	2 (4.5)	42 (95.5)	0 (0.0)	
Recognize Triatomine Picture[1]	64 (30.5)	137 (65.2)	9 (4.3)	
Males	50 (29.9)	110 (65.9)	7 (4.2)	0.362
Females	14 (32.6)	27 (62.8)	2 (4.6)	
Believed to Have Been Bitten[2]	5 (2.4)	183 (88.0)	20 (9.6)	
Males	2 (1.2)	150 (90.4)	14 (8.4)	0.037*
Females	3 (7.1)	33 (78.6)	6 (14.3)	

[1] Two individuals did not answer this question.

[2] Four individuals did not answer this question.

^All percentages are row percentages

[+]Cell count expected less than 5, used Fisher's Exact Test; when above 5, used Chi Square Test

Table 4. Frequencies of and Participation in Risk Behaviors Among Homeless Individuals in Houston, TX 2013 (N = 212).

Variable^+	YES no. (%)	NO no. (%)	P-value
Used Needles to Inject Drugs[1]	60 (28.4)	151 (72.6)	
Males	51 (30.5)	116 (69.5)	0.413
Females	9 (20.5)	35 (79.5)	
Shared Needles	32 (53.3)	26 (43.3)	
Males	27 (52.9)	22 (43.1)	0.833
Females	5 (55.5)	4 (44.4)	
Unregulated Tattoo(s)	93 (43.9)	119 (56.1)	
Males	77 (36.3)	91 (42.9)	0.307
Females	16 (7.6)	28 (13.2)	
Shared Tattoo Equipment[2]	5 (5.4)	73 (78.5)	
Males	4 (5.2)	62 (80.5)	0.428
Females	1 (6.2)	11 (68.8)	

[1] One participant refused to answer question about ever using needles to inject drugs

[2] All 93 who indicated receiving an unregulated tattoo answered question about sharing of needles or not

^ 'Don't Know' a viable answer choice for all variables in table but most variables had 0 people answering with this choice

[+]Cell count expected less than 5, used Fisher's Exact Test; when above 5, used Chi Square Test

Table 5. Risk Factors Associated With Believing to Have Been Bitted by a Triatomine Among Homeless Individuals in Houston, TX (N = 212).

Model: Believed to Have Been Bitten	Odds Ratio	95% Confidence Interval^
Sex, male	9.319	(0.643, 135.055)
Hispanic, Yes	0.066	(0.002, 2.138)
Race, Caucasian	0.132	(0.008, 2.217)
Chest Pain, Yes	0.031	(0.001, 0.828)*
Diagnosed Heart Condition, Yes	1.213	(0.095, 15.430)
Total Time Homeless	0.999	(0.996, 1.003)

^All variables assessed are based on biological plausibility. The full model force-includes all variables, regardless of significance.

Table 6. Risk Factors Associated With Recognition of Triatomine Picture Among Homeless Individuals in Houston, TX (N = 212).

Model: Recognize Triatomine Picture^	Odds Ratio	95% Confidence Interval
Sex	1.001	(0.416, 2.408)
Hispanic[+]	0.078	(0.002, 3.411)
Race	0.573	(0.292, 1.125)
Total Time Homeless	0.999	(0.998, 1.000)
Average Nights Outdoors Per Week	0.889	(0.784, 1.008)

^All variables assessed are based on biological plausibility. The full model force-includes all variables, regardless of significance.

[+]Cell count less than 5, corrected with Firth Correction

Table 7. Risk Factors Associated With Total Length Homeless Among Homeless Individuals in Houston, TX (N=212).

Model: Total Length Homeless^	Parameter Estimate	Standard Error	P-Value
Intercept	183.3	+/-56.6	0.0014
Sex	13.3	+/-54.4	0.8074
Hispanic	-84.2	+/-203.9	0.6801
Race	17.6	+/-45.6	0.7004
Used Needles to Inject Drugs	59.7	+/-51.0	0.2437
Received Unregulated Tattoo	-53.1	+/-42.8	0.2163
Received a Blood Transfusion	44.2	+/-55.2	0.4242

^ All variables assessed are based on biological plausibility. The full model force-includes all variables, regardless of significance.

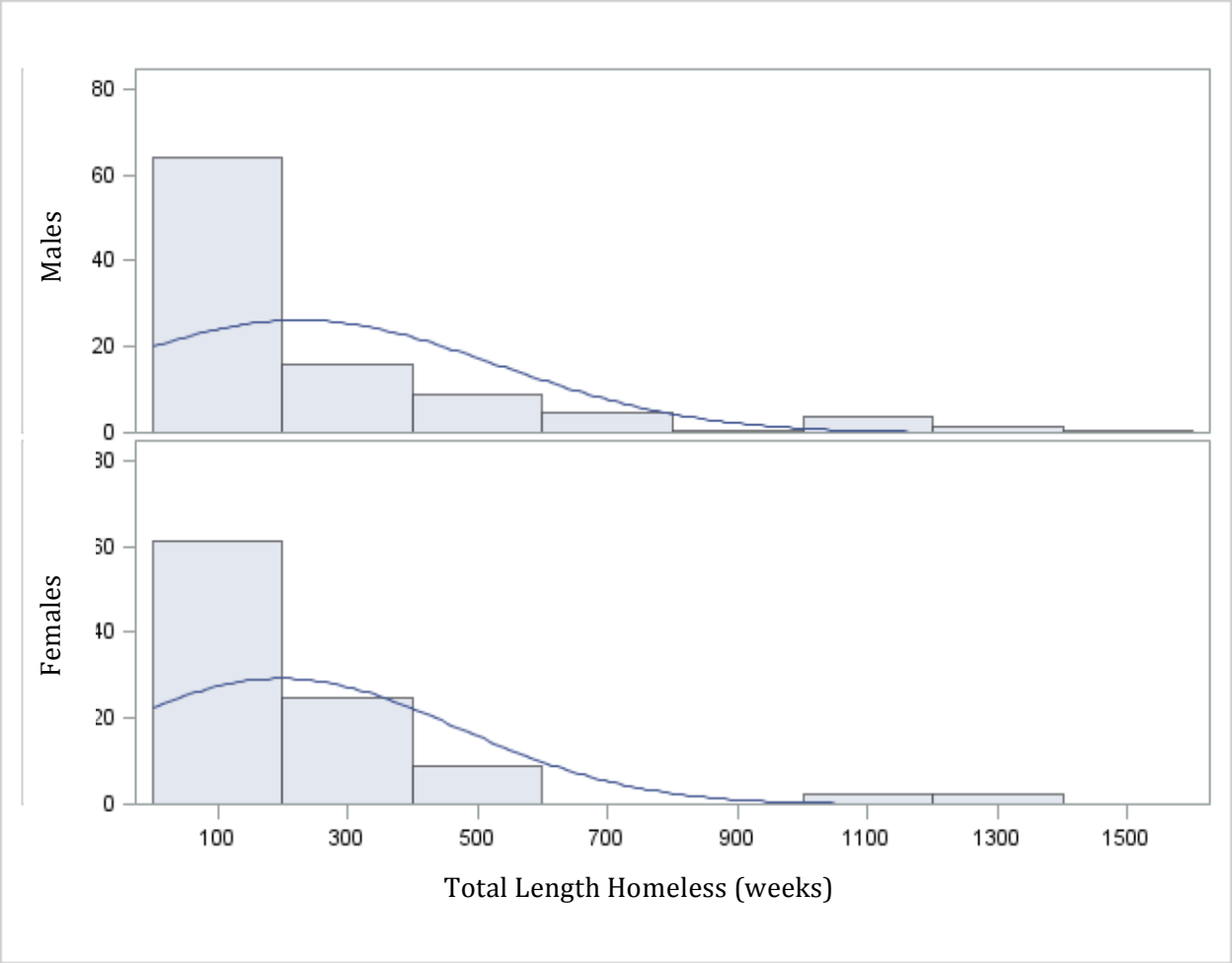
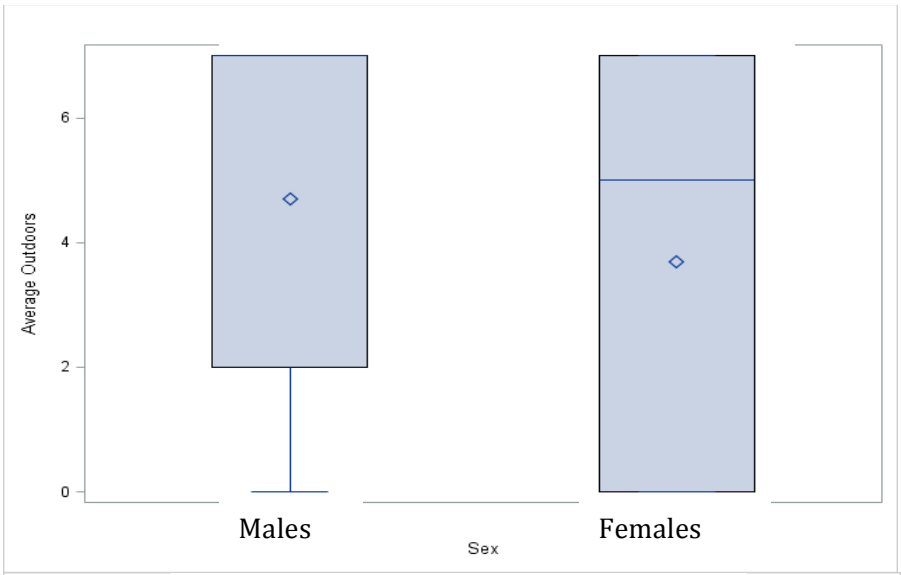


Figure 1: **Median total time homeless for males was different than for females among the sampled homeless population of Houston, TX (N= 212).** The x-axis represents the total length of time homeless in weeks, and the y-axis is the percent of individuals with the total length of time homeless. The top graph is for males, and the bottom graph is for females. Each bar is the percent of individuals with that total time homeless in weeks. The overlay is a normal curve, indicating that this is a non-parametric distribution. The range of total length homeless for both males and females was between 2 weeks to 1300 weeks (25 years). Males had a median total time homeless of 110 weeks (2 years), and females had a median total time homeless of 76 weeks (1.5 years).

A



B

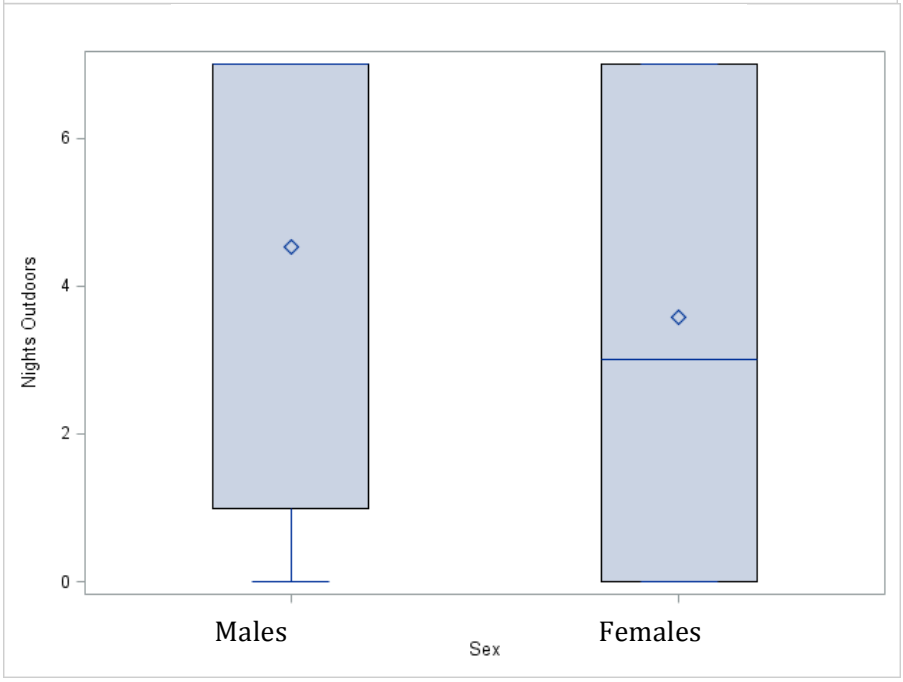


Figure 2: The number of nights slept outdoors in the past week is significantly different between males and females sampled from the homeless population of Houston, TX (N= 212). The line is the median number of nights spent sleeping outdoors. The diamond represents the mean number of nights spent sleeping outdoors. The box represents the upper and lower quartiles (75% and 25%). The whisker represents the absolute minimum value, which is 0 nights per week. A) Represents the number of nights spent sleeping outdoors per week for males and females. There was no significant difference detected between average number of nights slept outside per week for males and females. B) Represents the number of nights spent sleeping outdoors in the past seven nights for males and females. There was a significant difference between the number of nights spent sleeping outdoors in the past seven nights for males and females ($p = 0.022$).

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APPENDIX

Survey Instrument

Assessment of Socio-Demographic Information and Knowledge, Attitudes, and Behaviors About Chagas Disease Among the Homeless Population in Houston, Texas

Summer 2013

National School of Tropical Medicine

Baylor College of Medicine

Emory University, Rollins School of Public Health

TIME BEGUN (_ _ : _ _) AM/PM (circle one) Survey Site _____

DATE (_ _ / _ _/ _ _ _ _) MM/DD/YYYY Interviewer Initials: _ _ _

(Interviewer please read aloud to each respondent before survey is begun)

Hello. My name is ___(include name)___, and I will be conducting a survey today to assess knowledge, attitudes, and behaviors about Chagas disease. I am working with the National School of Tropical Medicine at Baylor College of Medicine and Emory University. The purpose is to gather information about people's background as well as people's knowledge and behaviors about Chagas. This disease is common in South America, but this survey will help to understand how the disease occurs in the Houston area. All of the information collected today will be used to help better understand this disease in the United States. Participation in this survey is completely voluntary and will only last about 10 minutes. All information will be kept confidential and will only be used by this institution. You are able to stop the survey at any time or refuse to answer certain questions. This survey may discuss difficult topics such as homelessness. Feel free to pause whenever you feel necessary.

(Note to interviewer)

First, before beginning survey, be sure to ask for informed consent. Also, make sure the participant meets the inclusion criteria of a) 18 years old or older and less than 90 years old and b) is currently homeless. Once consent has been given and indicated on survey, proceed. Please note that some questions have specific instructions. Some questions indicate a skip pattern with instructions and arrows to the next appropriate question. Please follow these patterns carefully because additional questions may be added or questions removed based upon a previous answer. Circle indicated answer for every question, or fill in appropriate numbers with correct units. Also, unless otherwise stated, please do not read the answer choices to the respondent but do remind at the beginning of the survey that "do not know" or "refuse to answer" are viable choices.

Interviewer say: Are you 18 years or older? (if yes), Are you currently without a permanent residence? (If yes to both of these questions, continue).

INFORMED CONSENT

Informed Consent: (*Interviewer:* after reading introduction, ask question A1)	
Are you voluntarily willing to participate in this survey?	Yes …… 1 No …… End Survey

(*Interviewer, begin survey if consent is given)*

Part A: Socio-Demographic Questions *Interview say*: First, I will begin by asking you questions about your employment, country of birth, and other questions about yourself.	
QUESTION	RESPONSE
A1. What year were you born?	_ _ _ _
A2. What is your sex?	Male …….. 1 Female …… 2 Don't Know…… 98 Refuse to Answer…… 99
A3. Are you of Hispanic, Latino, or Spanish origin?	Yes …….. 1 No …… 2 Don't Know…… 98 Refuse to Answer…… 99
A4. What is your race?	White/Caucasian ……1 African American ……2 American Indian or Alaska Native ……..3 Asian ……4 Mixed race……5 Other ……..6 Don't Know ……..98 Refuse to Answer ……99
A5. Where you born in the United States?	Yes …….. 1 → A8 No …….. 2 → A6 Don't Know …….. 98 → A8 Refuse to Answer ……. 99 → A8
A6. *(if no)* What is your country of birth?	_____
A7. When did you first arrive in the United States?	_ _ _ days/weeks/months/years (ago)
A8. What is the length of time, in total throughout your lifetime, you have been without a permanent dwelling or homeless?	_____ days/weeks/months/years *(interviewer:* please circle units in which respondent provides answers)

A9. Have you been homeless for more than a year?	Yes …… 1 → B1 No ……2 → A10 Don't Know ……..3 → A10 Refuse to Answer …….4 → A10
A10. Have you been homeless four times in the past three years?[102]	Yes …… 1 No ……2 Don't Know ……..3 Refuse to Answer …….4

Part B: Health History *(Interviewer say*:) Now, I will begin to ask you questions about your health history.	
QUESTION	RESPONSE
B1. Have you ever been diagnosed by a doctor with any type of heart condition?	Yes ……..1 No …… 2 Don't Know ……..98 Refuse to Answer ……. 99
B2. Have you had chest pains within the past 12 months?	Yes ……..1 No …… 2 Don't Know ……..98 Refuse to Answer ……. 99
B3. Do you have any type of health insurance, including Medicaid/Medicare, currently or have you had insurance within the past year?	Yes ……..1 →B4 No……..2 →B5 Don't Know ……..98 →B5 Refuse to Answer ……..99 →B5
B4. (*if yes)* What type of medical insurance do you have? (*interviewer:* read choices if necessary)	Medicare ……1 Medicaid ……2 Veteran's Benefits ……..3 Harris County Gold Card ……..4 Other ……..5 Don't Know ……..98 Refuse to Answer ……..99

[102] This is the definition of 'chronic homelessness' from the Coalition for the Homeless Houston.

B5. Where do you usually receive care or treatment for any health issues? (*interviewer:* read choices if necessary)	Emergency Room ……1 Community/Mobile Clinic ……2 Private Physician ……3 Local Pharmacy ……4 Does Not Seek Health Care ……5 Don't Know ……98 Refuse to Answer ……99
B6. Have you ever received a blood or blood product transfusion? (this includes platelets, red blood cells, immunoglobulin)	Yes ……1 → B7 No……2 → C1 Don't Know ……98 → C1 Refuse to Answer ……99 → C1
B7. When was this transfusion? (*interviewer: Place Xs in the date categories that were not provided by respondent. If multiple, gather year of each transfusion.)*	_ _ _ _ (YYYY)
B7. In which country was this transfusion performed? (*interviewer: if multiple, record all countries)*	_____

Part C: Knowledge about Chagas disease	
QUESTION	RESPONSE
C1. Have you ever heard of Chagas disease?	Yes ……1 → C2 No ……2 → C3 Don't Know ……98 → C3 Refuse to Answer ……99 → C3
C2. Where have you heard about Chagas disease?	Healthcare Professional ……1 Any type of school/class ……2 Friends ……3 Shelter Director/Employee ……4 Other……5 Don't Know ……98 Refuse to Answer ……99
C3. (*Interviewer: show respondent picture 1, 2)* I will now show you two pictures. Please take a look at it for whatever length of time you need. Do you recognize this insect as having seen it before? (most commonly known as triatomines or 'kissing bugs').	Yes ……1 → C4 No ……2 → C5 Don't Know ……98 → C5 Refuse to Answer …… 99 → C5

C4. Where have you seen this insect?	Shelter ……1 Park ……2 Home ……3 Other ……..4 Don't Know ……..98 Refuse to Answer …….99
C5. Have you ever been bitten by or fed on by this insect?	Yes ……..1 No ……..2 Don't Know ……..98 Refuse to Answer …….. 99

Part D: Travel History *(Interviewer say*:) Now, I will ask you questions about your travel history.	
QUESTION	RESPONSE
D1. Have you ever traveled or lived outside of the United States?	Yes ……..1 → D2 No ……2 →E1 Don't Know ……98 → E1 Refuse to Answer ….. 99 → E1
D2. (*if yes)*, Which countries have you traveled to? (*interviewer: record all countries stated)*	_____
D3. For each country you have traveled to, how long have you spent in each country (in weeks)?	_ _ _ _ days/weeks/months/years (*interviewer:* please circle units in which respondent provides answer)

Part E: Behaviors *(Interviewer say*:) Now, I will ask you some questions about your daily activities.	
E1. How many nights in the past week did you sleep outdoors, such as in a park or on a bench?	____ nights
E2. In a typical week, on average, how many nights per week do you sleep outside?	_____ nights

(*interviewer say:)* I will now ask you some sensitive questions. Remember, you are allowed to skip any questions you are not comfortable answering. All of your information will remain anonymous. E3. Have you ever used needles to inject drugs, either medical (such as insulin) or illicit?	Yes ……1 → E4 No ……2 → E11 Don't Know ……98 → E11 Refuse to Answer ……. 99 → E11
E4. How frequently do you inject drugs?	Daily ……1 Weekly ……2 Monthly ……3 Yearly ……4 Don't Know ……98 Refuse to Answer ……99
E5. Have you injected drugs in the past month?	Yes ……1 No ……2 Don't Know ……98 Refuse to Answer ……99
E6. About how long have you been or how long did you inject drugs?	1 month ……1 1 year ……2 Less than 5 years ……3 More than 5 years ……4 Don't Know ……98 Refuse to Answer ……99
(*interviewer say):* I just wanted to remind you that all information you tell us will be completely anonymous and will not be connected to you in any way. E7. When you have injected drugs, have you ever shared needles or injection materials with anyone?	Yes ……1 → E8 No ……2 → E10 Don't Know ……98 → E10 Refuse to Answer ……99 → E10
E8. Have you shared a needle or injection materials within the past 3 months?	Yes ……1 No ……2 Don't Know ……98 Refuse to Answer ……99
E9. (*interviewer: if yes to E7*) How often do you share needles or other injection equipment for purposes of medical or drug use?	Rarely ……1 Occasionally ……2 Often ……3 Don't Know ……98 Refuse to Answer ……99

E10. Where do you normally receive your needles or injection equipment used for injecting medicine or drugs? (*interviewer:* read choices if necessary)	Health Clinic (doctor, nurse, etc.)……..1 Pharmacy ……2 Trash/Found Needle ……3 Peer/Friend/Acquaintance ……4 Other ……5 Don't Know ……98 Refuse to Answer ……99
E11. Have you ever received a tattoo, other than in a shop with regulated equipment?	Yes ……1 → E12 No ……2 → END Don't Know ……98 → END Refuse to Answer ……99 → END
E12. (*interviewer: if yes*) Where did you receive this tattoo? (*interviewer:* read choices if necessary)	Home/Residence ……1 Prison Facility ……2 Street ……3 Don't Know……98 Refuse to Answer ……99
E13. What material was primarily used to create this tattoo? (*interviewer:* read choices if necessary)	Safety Pins ……1 Guitar Strings ……2 Paper Clips ……3 Staples ……4 Other ……5 Don't Know ……98 Refuse to Answer ……99
E14. Did other individuals receive a tattoo, either before or after your tattoo, with this same material?	Yes ……1 → END No ……2 → END Don't Know ……98 → END Refuse to Answer ……99 → END

-END-

END SURVEY

(Interviewer say): The survey is now complete. Thank you very much for your time and participation in this

(*interviewer:* all answers concerning days/weeks/months/years will be calculated into standard units for analysis.)

TIME ENDED (_ _ : _ _) AM/PM (circle one)

Photo 1[103]: to scale, as compared to a penny

Photo 2[104]: actual size

[103] S. Kjos. CDC. July 5, 2012. http://www.cdc.gov/parasites/chagas/gen_info/vectors/
[104] Gathany, James. CDC. July 5, 2012. http://www.cdc.gov/parasites/chagas/gen_info/vectors/

IRB Approval

EMORY UNIVERSITY | Institutional Review Board

June 14, 2013

Alexandra Ingber
Principal Investigator
Public Health

RE: **Exemption of Human Subjects Research**
IRB00066083
Baseline Knowledge, Attitudes, and Behaviors Related to Chagas Disease Among Homeless Individuals in Houston, Texas

Dear Ms. Ingber:

Thank you for submitting an application to the Emory IRB for the above-referenced project. Based on the information you have provided, we have determined on 6/14/2013 that although it is human subjects research, it is exempt from further IRB review and approval.

This determination is good indefinitely unless substantive revisions to the study design (e.g., population or type of data to be obtained) occur which alter our analysis. Please consult the Emory IRB for clarification in case of such a change. Exempt projects do not require continuing renewal applications.

This project meets the criteria for exemption under 45 CFR 46.101(b)(2). Specifically, you will survey homeless people in Houston, Texas, in order to determine their baseline knowledge, attitudes, and behaviors for high risk of Chagas disease.

A waiver of documentation of informed consent has been granted for this study. The following protocol and consent documents were included in this review:

- Protocol, *version 5/4/2013 (modified 6/4/2013)*
- Information Sheet, *version 4/10/2013 (modified 6/7/2013)*
- Script for Oral Consent, *version 5/4/2013 (modified 6/7/2013)*

Please note that the Belmont Report principles apply to this research: respect for persons, beneficence, and justice. You should use the informed consent materials reviewed by the IRB unless a waiver of consent was granted. Similarly, if HIPAA applies to this project, you should use the HIPAA patient authorization and revocation materials reviewed by the IRB unless a waiver was granted. CITI certification is required of all personnel conducting this research.

Unanticipated problems involving risk to subjects or others or violations of the HIPAA Privacy Rule must be reported promptly to the Emory IRB and the sponsoring agency (if any).

In future correspondence about this matter, please refer to the study ID shown above. Thank you.

Sincerely,

Tom Penna, CIP
Research Protocol Analyst
This letter has been digitally signed

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