



Chagas Disease in Pregnant Women in the Peruvian Amazon Basin. Cross-Sectional Study

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Aims: To assess the prevalence of Chagas disease in pregnant women in Iquitos City, Peru.

Material and Methods: Cross-sectional survey in 300 pregnant women in Iquitos (Peru) from 1 May 2019 to 15 June 2019. Women were tested using an ELISA serology test.

Results: Serology was positive in one case (prevalence: 0.33%; 95% confidence interval: 7.1–13.9%), of a 25-year-old woman who lived in a wooden house with a leaf roof in a periurban area of Iquitos. She was familiar with kissing bugs and had chronic, asymptomatic Chagas disease.

Conclusion: The prevalence of Chagas disease is low in the urban and peri-urban area of the city of Iquitos.

Keywords: Chagas disease, *Trypanosoma cruzi*, pregnant, Peru, Amazon

INTRODUCTION

Chagas disease is a systemic chronic parasitic infection caused by *Trypanosoma cruzi* that affects 6–7 million people in Central and South America. It is considered a neglected tropical disease and has a high public health impact in the area.

While mainly vector-borne, Chagas disease can also be spread via blood transfusion, transplantation, or from mother to child (1). The latter, congenital route is frequent and especially relevant in areas where there is no vector transmission by insects or blood transfusion. To accelerate the elimination of this transmission route, strategies and methods should be applied to screen, diagnose, and treat all infected pregnant women as well as their newborns and, where appropriate, other children as soon as possible (2).

Chagas disease is endemic throughout the Pacific southwest of Peru, known as the Greater Southern Region, in the departments of Arequipa, Moquegua, Tacna, Ayacucho and Apurímac.

In the past decade, widespread infestation with the vector *Triatoma infestans* and active transmission of Chagas disease to humans have been documented in this area (3, 4). In addition, the northeastern departments of Cajamarca, Amazonas, San Martín, and Ucayali (400–1,000 m above sea level) have also detected the thriving presence of the *Panstrongylus herreri* vector (3). However, there is little knowledge about the prevalence and epidemiology of *Trypanosoma cruzi* in northern Peru (5); the most significant resources have been allocated toward research and control efforts in the south (5).

Iquitos is a city in the Peruvian Amazon Basin, in the Department of Loreto and near the confluence of the Marañon and Ucayali rivers. A few isolated cases of Chagas disease have been documented in the town and surroundings areas (6), but no survey has ever focused on the pregnant population. As these women can unknowingly transmit the disease to their newborns, its detection is highly recommended (2, 7). The aim of this study was to estimate the prevalence of Chagas disease in pregnant women in Iquitos, Peru, in the Peruvian Amazon basin.

METHODS

Setting and Study Period

We performed a cross-sectional survey of Chagas disease, strongyloidiasis, and human T-cell leukemia-lymphoma virus (HTLV) infection in an urban and periurban area of Iquitos (Peruvian Amazon) (Figure 1), from 1 May 2019 to 15 June 2019.

Study Population

We included pregnant women attending the health centers in four districts of the greater Iquitos area, located in the Peruvian Amazon. Participants were adults over the age of 18 years and were selected through convenience sampling (i.e., on days when the researcher was at the health center) when they visited the midwife during prenatal check-ups. All participants were informed about the screening and signed informed consent.

Data Collection

On enrollment, participants were asked about sociodemographic variables and their familiarity with Chagas disease. We obtained a blood sample for serological detection of *T. cruzi* antibodies, *S. stercoralis* IgG antibodies, and HTLV antibodies, and a stool sample to test for parasitic infections. Our group published results on the prevalence of strongyloidiasis and other intestinal parasites in a parallel report (8).

Detection of *T. cruzi* IgG antibodies was performed by two different assays: the Chagatest ELISA lysate (Wiener, Rosario, Argentina) and the Chagatest ELISA recombinant v.4.0 (Wiener, Rosario, Argentina). *T. cruzi* infection was considered confirmed if both tests yielded a positive result, while participants were considered seronegative when both tests yielded negative results. Specimens with only one positive test were considered inconclusive. The Chagatests were completed according to manufacturer's instructions and the threshold for positive results was 0.10 optical density (OD) units above the mean absorbance of two negative control specimens included on each plate.

Data Analysis

The collected data were systematically recorded and analyzed using IBM SPSS Statistics, version 22.0. We used the chi-squared test or Fisher's exact test to determine the presence of Chagas disease according to several demographic variables, considering results to be significant where the $P < 0.05$.

RESULTS

The study included 300 pregnant women with a mean age of 26.7 years (standard deviation [SD] 6.4; range 13–38), mean of number of deliveries of 2.9 (SD: 1.7), and a mean gestation period of 172 days (SD: 59). Just under half (44.7%) lived in peri-urban areas, while the rest lived in the city. Table 1 shows the sociodemographic and epidemiological characteristics of the participants in the study. Figure 1 Health centers in Iquitos city and surrounding area.

Four participants tested positive on the Chagatest ELISA recombinant v.4.0 with titers > 0.2 , but only one had a second positive serology test (Chagatest ELISA lysate) (Table 2). Therefore, just one participant (0.33%, 95% CI: 0.02–2.13%) was considered as a definitive positive for Chagas disease. Three other participants had inconclusive results by both ELISAs. Their infection status therefore remained unresolved, and their data were excluded from further analysis. There were no statistically significant differences in the sociodemographic conditions, knowledge of Chagas disease, or housing conditions in cases with positive and negative serology against *T. cruzi*.

The positive case was a 25-year-old woman who lived in a periurban area of Iquitos (Figure 1). She had been living in the same house—a wooden construction with a leaf roof—for the last 5 years. She had two other children and was familiar with the “chirimacha” (kissing bugs or triatomines) and reported seeing them at home, but she did not remember being bitten by one. She had not received any blood transfusion and did not have any symptoms of Chagas disease (chest pain, palpitation, dysphagia). Her electrocardiogram was normal, showing a repolarization disorder.

DISCUSSION

Our study demonstrates that the prevalence of asymptomatic Chagas disease in pregnant women is low (0.33%) in the Iquitos area of the Peruvian Amazon Basin. This evidence helps to fill gaps in knowledge arising from the few seroprevalence studies in pregnant women in Peru (7). In 2005, a study performed in Arequipa (southern Peru) in 3,000 pregnant women showed serological positives in 22 (0.7%) participants; only one newborn was IgM positive (9).

The prevalence of Chagas disease in pregnant women, both in our study and the one performed in Arequipa, is low compared to those performed in Bolivia, northern Argentina, or Brazil, which have reported a prevalence of 21, 12.1, and 1.1%, respectively (10–12). In the general population, the literature reports a seroprevalence of Chagas disease in the southern department of Arequipa ranging from 2 to 5.8% (4, 13, 14). In



FIGURE 1 | Health centers in Iquitos city and surrounding area.

the north (La Joya and Cajamarca departments), prevalence is slightly higher, between 7.6 and 14.9% (5, 15). Our results from Iquitos are sensibly lower than in these reports from elsewhere in Peru.

However, our results are relevant because they show that Chagas disease, although uncommon, is actually present in the Iquitos area. Asymptomatic Chagas disease cases like the one detected in our survey do occur. Other acute cases have previously been reported in 2006 and 2008 in the Amazon area (6, 16, 17). Therefore, Chagas disease is present not only in the jungle of northern Peru (5) but also in the Amazon basin. That

said, seroprevalence of *T. cruzi* in pregnant women appears to be lower than that reported in the endemic areas of Peru (9). There may be small pockets of vector transmission of Chagas disease in Iquitos. Performing small studies around this case could help to uncover more; this adaptive strategy could efficiently identify secondary cases (13).

Chagas disease has been studied elsewhere in the Amazon basin, including in Ecuador [prevalence 3.6% (18)] and in Brazil (seroprevalence 1.5%). Throughout all these areas, Chagas continues to pose a threat to public health, one amplified by deforestation and its associated changes in transmission vectors

(19, 20). Indeed, this region is at risk of transmission due to triatomine-contaminated food (21). Several initiatives, like the Iniciativa Andina (IA), have been launched in priority areas of Latin America to ensure the interruption of vector-borne transmission of Chagas as well as to improve surveillance and disease prevention (22).

The presence of pregnant women in the Amazon Basin who are at risk of congenital transmission to the fetus, along with other reported cases of acute Chagas Diseases (6, 16, 17) should serve as a warning of an (emerging) problem in this area of Peru. While the low prevalence does not justify screening in pregnant or puerperal women, other measures are called for. WHO/PAHO recommends interventions to disrupt vector transmission, including the elimination of the triatomines or other vectors from the study area; another possibility is assessing seroprevalence of *T. cruzi* infection in children 5 or younger (23). Several environmental and social factors may also directly or indirectly influence the biology and behavior of triatomines (24). Spatial clustering of infestation in the

urban context may both challenge and inform surveillance and control of vector reemergence after insecticide intervention. These measures have been performed in several departments in Peru, such as Moquegua and Tacna, which were subsequently declared free of vector transmission by the WHO/PAHO (25).

Entomologic investigation of *T. infestans* and other triatomines is important for knowing the ecology of vector transmission (26). It is important to implement measures for controlling transmission of *T. cruzi* by triatomines in the Amazon basin, with vector surveillance and control with insecticide as has been happening in other parts of Peru (5). In light of our exploratory results and other cases reported in the area, it could be of interest to perform similar studies to those carried out in other parts of Peru (15, 17, 23). Another topic to investigate in the area is dogs, which are important reservoirs of *T. cruzi* and may play a role in reinitiating transmission in previously sprayed areas. Dogs may also serve as indicators of reemerging transmission (24).

Another potential line of research about Chagas disease in the Peruvian Amazon basin is the risk of oral transmission. In Brazil, Venezuela, Colombia, Bolivia, and French Guiana, several outbreaks of orally transmitted Chagas disease have been reported; these have been epidemiologically associated with the consumption of beverages like açai juice (the fruit from a species of palm tree) or sugar cane juice (27). Some cases of Chagas disease have also been described in young indigenous people who drank contaminated juice (17, 26). This line of research should continue in the area, as should health education, in order to prevent the contamination of juice with *T. infestans* excreta (26).

This study has some limitations. First, a complete study of congenital transmission was not performed. Secondly, there were three participants with borderline results according to both ELISAs. As this situation might reflect a window period, it would be necessary to re-test them after 6 months to confirm or rule out infection. Finally, there was no entomologic investigation about species living at the patient's home.

CONCLUSIONS

Although the prevalence of Chagas disease is low in the urban and peri-urban area of the city of Iquitos, it is relevant to advise local authorities that the disease is actually present in the Peruvian Amazon Basin in pregnant women with a risk of congenital transmission. Our results indicate a probable low rate,

TABLE 1 | Epidemiological characteristics of pregnant women.

Variables	Frequency
Sociodemographic conditions	
Mean age (years)	26 (SD: 6.4)
Mean time living in the place (years)	9.9 (SD: 9.7)
Residence in rural area	134 (44.7%)
Characteristics of pregnancy	
Mean gestational age (days)	172 (SD: 59)
Primiparous	64 (21.3%)
Mean number of pregnancies	2.9 (SD: 1.7)
Mean number of children alive	1.8 (SD: 1.5)
Risk factors for Chagas disease	
History of blood transfusion	15 (5.0%)
Knowledge of Chagas disease	
Any knowledge about Chagas disease	10 (3.3%)
Contact with person with Chagas disease	0 (0.0%)
Characteristics of living houses	
Wood house	286 (95.3%)
Leaf roof	234 (78.0%)
Soil floor	89 (29.7%)

SD, standard deviation.

TABLE 2 | Results of two serological procedures in positive cases.

Code	Age/health center	Antecedents blood transfusion	Chagatest ELISA recombinant v.4.0 titers	Chagatest ELISA lysate titers	Chagas disease
1	25 years/santa clara	No	1.118	1.416	Yes
2	19 years/san juan	No	0.267	0.011	Inconclusive
3	33 years/san juan	No	0.237	0.029	Inconclusive
4	19 years/San juan	No	0.301	0.038	Inconclusive

but it is necessary to perform more studies and monitor the prevalence of the disease.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Ethics Committee of the General University Hospital of Alicante (Spain) approved the project (PI2018/113), as did the Ethics Committee of Loreto Regional Hospital in Iquitos (Peru) (027-CIEI-HRL-2019). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

J-MR-R: conceptualization, formal analysis, methodology, project administration, supervision, writing—original draft, writing-review and editing, designed the study, analyzed clinical data, prepared, and reviewed the manuscript. SO-M: formal analysis, investigation, project administration, software, supervision, writing—original draft, and writing-review and editing. M-EV-C: methodology and writing-review and editing. O-NG-P: data citation, software, supervision, and writing-review and editing. V-VP-C: data curation, methodology, project administration, and writing-review and editing. CR-A: investigation and writing-review and editing. MG-H-M: conceptualization, writing—original draft, and writing-review and editing. MC-M: conceptualization, project administration, writing—original draft, and writing-review and editing manuscript. All authors contributed to the article and approved the submitted version.

REFERENCES

- Pérez-Molina JA, Molina I. Chagas disease. *Lancet*. (2018) 391:82–94. doi: 10.1016/S0140-6736(17)31612-4
- Organización Panamericana de la Salud. Nuevas generaciones sin la infección por el VIH, la sífilis, la hepatitis B y la enfermedad de Chagas en las Américas 2018. *ETMI Plus*. Washington, DC: OPS (2019).
- Cornejo JG, Carpio D. *The Chagasic Endemic Situation in Peru*. (2003). Available online at: <http://www.fac.org.ar/tcvc/llave/c296/cornejo.PDF> (accessed May 10, 2020).
- Bowman NM, Kawai V, Levy MZ, Cornejo del Carpio JG, Cabrera L, Delgado F, et al. Chagas disease transmission in periurban communities of arequipa, Peru. *Clin Infect Dis*. (2008) 46:1822–8. doi: 10.1086/588299
- Alroy KA, Huang C, Gilman RH, Quispe-Machaca VR, Marks MA, Ancca-Juarez J, et al. Prevalence and transmission of trypanosoma cruzi in people of rural communities of the high jungle of Northern Peru. *PLoS Negl Trop Dis*. (2015) 9:e0003779. doi: 10.1371/journal.pntd.0003779
- Cabrera R, Vega S, Cáceres AG, Ramal AC, Álvarez C., Ladera P, et al. Epidemiological investigation of an acute case of chagas disease in an area of active transmission in Peruvian Amazon region. *Rev Inst Med Trop São Paulo*. (2010) 52:269–72. doi: 10.1590/S0036-46652010000500009
- Velarde C-N. [Chagas disease in Peru: congenital transmission]. *Rev Soc Bras Med Trop*. (2005) 38(Suppl 2):55–7.
- Ortiz-Martínez S, Ramos-Rincón JM, Vásquez-Chasnamote ME, Alarcón-Baldeón JJ, Parraguez-De-La-Cruz J, Gamboa-Paredes ON, et al. A cross-sectional study of seroprevalence of strongyloidiasis in pregnant women (Peruvian amazon basin). *Pathogens*. (2020) 9:348. doi: 10.3390/pathogens9050348
- Mendoza Ticona CA, Córdova Benzaquen E, Ancca Juárez J, Saldaña Díaz J, Torres Choque A, Velásquez Talavera R, et al. Prevalencia de la enfermedad de Chagas en puérperas y transmisión congénita en una zona endémica del Perú. *Rev Panam Salud Pub Pan Am J Public Heal*. (2005) 17:147–53. doi: 10.1590/S1020-49892005000300001
- Rendell VR, Gilman RH, Valencia E, Galdos-Cardenas G, Verastegui M, Sanchez L, et al. Trypanosoma cruzi-infected pregnant women

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- without vector exposure have higher parasitemia levels: Implications for congenital transmission risk. *PLoS ONE*. (2015) 10:e0119527. doi: 10.1371/journal.pone.0119527
11. Contreras S, Fernandez MR, Agüero F, Dese Dese J, Orduna T, Martino O. Congenital chagas-mazza disease in salta, argentina. *Rev Soc Bras Med Trop*. (1999) 32:633–6. doi: 10.1590/S0037-8682199900600004
 12. Martins-Melo FR, da Silveira Lima M, Ramos AN, Alencar CH, Heukelbach J. Systematic review: prevalence of chagas disease in pregnant women and congenital transmission of *Trypanosoma cruzi* in Brazil: a systematic review and meta-analysis. *Trop Med Int Heal*. (2014) 19:943–57. doi: 10.1111/tmi.12328
 13. Levy MZ, Kawai V, Bowman NM, Waller LA, Cabrera L, Pinedo-Cancino VV, et al. Targeted screening strategies to detect *Trypanosoma cruzi* infection in children. *PLoS Negl Trop Dis*. (2007) 1:e103. doi: 10.1371/journal.pntd.0000103
 14. Hunter GC, Borrini-Mayori K, Ancca Juárez J, Castillo Neyra R, Verastegui MR, Malaga Chavez FS, et al. A field trial of alternative targeted screening strategies for chagas disease in Arequipa, Peru. *PLoS Negl Trop Dis*. (2012) 6:e1468. doi: 10.1371/journal.pntd.0001468
 15. Delgado S, Neyra RC, Machaca VRQ, Juárez JA, Chu LC, Verastegui MR, et al. A history of Chagas disease transmission, control, and re-emergence in peri-rural La Joya, Peru. *PLoS Negl Trop Dis*. (2011) 5:e970. doi: 10.1371/journal.pntd.0000970
 16. Asayag CR, Garay CR, Meza Sanchez G, Angeles C, Jara Baca C, Evans C, et al. Images in clinical tropical medicine eight year old with fever, hepatomegaly, and positive thick smear. *Am J Trop Med Hyg*. (2008) 79:473. doi: 10.4269/ajtmh.2008.79.473
 17. Cabrera R, Vega S, Valderrama Y, Cabanillas K, Fernández C, Rodríguez O, et al. New focus of active transmission of Chagas disease in indigenous populations in the Peruvian Amazon basin. *Rev Soc Bras Med Trop*. (2013) 46:367–72. doi: 10.1590/0037-8682-1195-2013
 18. Amunarriz M, Quito S, Tandazo V, López M. Seroprevalencia de la enfermedad de chagas en el cantón Aguarico, Amazonia ecuatoriana. *Rev Panam Salud Pub Pan Am J Public Heal*. (2010) 28:25–9. doi: 10.1590/S1020-49892010000700004
 19. Magalhães BML, Coelho LIARC, Maciel MG, Ferreira JMBB, Umezawa ES, Coura JR, et al. Inquérito sorológico para doença de chagas em áreas rurais de Manaus, Coari e Tefé na Amazônia Ocidental. *Rev Soc Bras Med Trop*. (2011) 44:697–702. doi: 10.1590/S0037-86822011000600009
 20. Castro MCM, Barrett TV, Santos WS, Abad-Franch F, Rafael JA. Attraction of Chagas disease vectors (Triatominae) to artificial light sources in the canopy of primary Amazon rainforest. *Mem Inst Oswaldo Cruz*. (2010) 105:1061–4. doi: 10.1590/S0074-02762010000800019
 21. Pinto AYDN, Valente SA, Valente VDC, Ferreira AG, Coura JR. Fase aguda da doença de Chagas na Amazônia brasileira. Estudo de 233 casos do Pará, Amapá e Maranhão observados entre 1988 e 2005. *Rev Soc Bras Med Trop*. (2008) 41:602–14. doi: 10.1590/S0037-86822008000600011
 22. Anonimous. X. *Reunión de la Comisión Intergubernamental de la Iniciativa Andina de Control de la Transmisión Vectorial y Transfusional de la Enfermedad de Chagas IPA-y VI Reunión de la Iniciativa Gubernamental de Vigilancia y Prevención de la Enfermedad de Chagas en*. (2020). Available online at: <https://www.paho.org/hq/dmdocuments/2012/X-Reunion-AMCHA-2011.pdf> (accessed June 2, 2020).
 23. Buttenheim AM, Levy MZ, Castillo-Neyra R, McGuire M, Toledo Vizcarra AM, Mollesaca Riveros LM, et al. A behavioral design approach to improving a Chagas disease vector control campaign in Peru. *BMC Pub Health*. (2019) 19:1272. doi: 10.1186/s12889-019-7525-3
 24. Castillo-Neyra R, Chou Chu L, Quispe-Machaca V, Ancca-Juarez J, Malaga Chavez FS, Bastos Mazuelos M, et al. The potential of canine sentinels for reemerging *Trypanosoma cruzi* transmission. *Prev Vet Med*. (2015) 120:349–56. doi: 10.1016/j.prevetmed.2015.04.014
 25. Náquira C. [Urbanization of Chagas disease in Peru: experiences in prevention and control]. *Rev Peru Med Exp Salud Pub*. (2014) 31:343–7.
 26. Cabrera R, Valderrama Y, Meza JR. Perception about chagas disease and the risk of oral transmission in Andoas, Loreto, Peru. *Rev Peru Med Exp Salud Pub*. (2020) 37:174–5. doi: 10.17843/rpmpesp.2020.371.4875
 27. Andrade DV, Gollob KJ, Dutra WO. Acute Chagas disease: new global challenges for an old neglected disease. *PLoS Negl Trop Dis*. (2014) 8:e3010. doi: 10.1371/journal.pntd.0003010
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