



Research Article

Socioeconomic Determinants of Chagas Disease in an Endemic Zone in Western Mexico

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Abstract

Background and Objectives: Chagas disease (ChD) is traditionally associated with poverty and ignorance. However, we do not have hard evidence about this phenomenon. Our objective was to estimate ChD's seroprevalence in western Mexico, analyzing its association with socio-demographic variables. **Methods:** We surveyed 1264 habitants of 58 rural and urban localities in Jalisco, Colima, and Nayarit, Mexico, identifying the ChD through indirect hemagglutination and Western Blot tests. We recorded socio-demographic and house characteristics, analyzing their association with ChD using Multiple Logistic Regression. **Results:** We found 85 ChD cases (seroprevalence of 6.7%). We found a significant correlation with low SES young females in rural areas (OR= 3.28; p= 0.002). However, no significant association of ChD with the SES, the SL, or the house's quality was noticed. **Conclusion:** Young women living in rural areas with a low SES represent a risk population that deserves attention for preventive programs. We did not find an association of ChD with the rest of the variables in persons older than 31 years, suggesting that ChD transmission in this region is not a predominantly poverty or ignorance problem.

Keywords: Chagas disease; Sociodemographic variables; Mexico

Introduction

Chagas Disease (ChD) is an originally sylvatic parasitic infection caused by the hemoflagellated protozoan *Trypanosoma cruzi* (Tc). The parasite is transmitted by hematophagous insects of the subfamily Triatominae (Hemiptera, Reduviidae), constituting a Nested infection that involves diverse wild mammals [1,2] and eventually humans, in whom the parasite produces the acute or chronic forms of ChD. Identifying those human populations at risk of infection allows prioritizing strategies to control or prevent ChD

[3]. Many authors have postulated that transmission to humans occurs mainly in rural settlements with deprived housing in impoverished regions, usually in huts made of adobe, with dirt floors or palm roofs, surrounded by corrals of domestic animals, resembling its original nidus [4,5]. However, hard evidence concerning the association between poverty, marginalization, low education, and inadequate housing with ChD prevalence is scarce and not directly correlated to ChD, but only to Triatomine infestation.

In Mexico the average prevalence of ChD is estimated around 3.3% [6], especially in states of the country considered the poorest, such as Chiapas, Veracruz, Oaxaca, and Guerrero, where we found the highest ChD rates [7]. However, in the western Pacific

ic coast, with higher SES and SL, many authors have documented ChD in urban communities [8,9]. To analyze specifically the association between ChD prevalence with the SES, SL, Sex, Age, housing and labor conditions, we carried out a serosurvey in rural and urban settlements in Jalisco, Nayarit, and Colima in the western region of Mexico.

Methods

Target population and study design

We performed a population based cross-sectional seroepidemiological survey among Jalisco, Colima, and Nayarit inhabitants in western Mexico (see figure 1) from September 2010 to May 2011. The studied area comprises approximately 112000 km², with 9 723 667 inhabitants [10]. In total, we selected 58 urban and rural localities in the region, sampling 1264 subjects.



Fig 1. Map of Mexico, the studied region in the states of Jalisco, Colima and Nayarit. As well as the 58 sampled localities in the 3 states

Figure 1: Map of Mexico and the states of Jalisco, Colima and Nayarit with the 58 sampled localities between 2010 and 2011.

We applied a structured questionnaire and took a venous blood sample to identify anti-Tc antibodies using the Indirect Hemagglutination (IHA) and the Western Blot (WB) test in approximately twenty people randomly selected in each locality from an average of ten houses. The inclusion criteria were: age from 1 to 85 years; with all their lifespan or approximately ten years of permanent residence in the locality (to link a prolonged exposure time with environmental factors in the community, and to minimize the possible effect of carrying Tc from other places). We excluded patients with severe chronic disease or contraindication for venipuncture.

Laboratory test

We separated serum from blood samples and stored at -70 °C until their process. Then, our team performed IHA with the commercial kit (Chagatest, Wiener Labs®) following the manufacturer instructions treating the samples with 2-mercaptoethanol (2-ME) dilution of 1:40, considering a specimen positive when agglutination occurred at a dilution 1:40 or higher. The positive IHA samples and a stock of negative cases were analyzed using the WB test with a standard immunoelectrotransference technique [11] in the National Institute of Cardiology Ignacio Chavez in Mexico City. We considered ChD's cases those with two positive tests, expressing this in a nominal dichotomous scale.

Socioeconomic variables

Socioeconomic Status (SES): We considered four categories according to the Mexican Association of Opinion and Marketing [12], this includes the occupation of the head of the family; access to urban services; quality of housing; spending on education, leisure and health. The categories were: 1. High SES: People with skilled jobs, complete houses, public services, and access to private medical care or insurance; 2. Medium SES: Those persons with a formal job and beneficiaries of public social security, but with modest housing and without automobile; 3. Poverty level: Family's head dedicated to informal commerce and non-qualified or elementary jobs, with poor housing conditions and more than three people per room; and finally 4. Extreme poverty: People living in incomplete houses, with meager income, many of them working as peasants or unemployed. In each family, we included all the participant members under the same category.

School Level (SL): We considered it only in older than 11 years and stratified them in four categories: 1. Without schooling (individuals with no or incomplete primary education); 2. High school, or early technical education; 3. Technical or administrative careers; and 4. People with higher education as professionals or postgraduate.

Occupation: We stratified this variable in people older than 18 years in six different groups according to the International Standard Classification of Occupations (ISCO) [13]: a. Field workers, including farmers, peasants, fishers; b. Services and Sales, like store clerks, street vendors, musicians, waiters, etcetera; c. Managers and professionals; d. Workers in Factories, masons, mechanics, craftsman; e. Students; and f. House workers including homemakers and maids

Type of locality: The categories were: 1. Rural towns with less than 2500 inhabitants, and 2. Urban localities with more than 2600 inhabitants (up to 820,000) according to the INEGI11.

Animals at home: We considered the presence of pets, farmyard or stable animals (poultry, pigs, horses, cows, goats) inside house or in backyard.

House characteristics: We stratify it according to the construction material and the house's finishes that could favor the infestation of triatomines. For this, we considered the materials of Ceiling, Walls, and Floor, being the worse those with a dirt floor, no plastered walls or roof made of palm or cardboard, and the best, houses made of plastered bricks, ceramic floor and house commodities like conditioned air or internet connection.

Inhabitants per room- Two or less people per room, or more than three persons per room.

Statistical analysis

We carried out the correlation analysis of ChD seroprevalence with gender, age, SL, SES, house characteristics, animal ownership, type of settlement, and occupation using Multivariate Logistic Regression, with estimation of Odds Ratio (OR) and their

Confidence Intervals to 95% (CI95%) with the Woolf's method.

Ethical aspects: The institutional committees for Ethics and Research of the Secretary of Health in Colima, Jalisco and Nayarit approved the protocol (#142/09). We obtained written informed consent from all participants (parents or legal guardians in the case of minors) before administration of the questionnaire or blood sampling.

Results

We obtained 1264 valid samples, of which 85 resulted positive to ChD, representing a prevalence of 6.72% (CI95%: 5.4 to 8.25). Table 1 shows the total individuals' social and demographic conditioning factors and their entailment with Tc infection. We sampled 371 men in whom 18 were positive for ChD (4.85%), meanwhile in 893 females, we observed 67 ChD cases (7.5%), although such difference was not significant. It is noteworthy that only the age group between 11 and 40 years had a significantly higher prevalence than the other groups, including the elder.

Variable	Sampled	ChD	Univariate OR (CI 95%)	Multivariate OR (CI95%)
Sex				
Male	371	18	1.6 (0.93- 2.7)	0.99 (0.97- 1.003)
Female	893	67		
Age				
1- 10 years	26	0	0.99 (0.98- 1.003)	1.5 (0.92- 2.7)
11- 20	157	16		
21- 30	224	20		
31- 40	271	16		
41- 50	204	12		
51- 60	169	9		
61- 70	136	8		
71- 80	61	4		
> 81	16	0		
Socioeconomic Status				
High	116	9	0.83 (0.61- 1.13) ²	0.8 (0.51- 1.27)
Medium	627	45		
Low	459	29		
Extreme poverty	62	2		
School level				

None	392	22	0.88 (0.68- 1.15) ³	1.01 (0.56- 1.8)
Elementary	635	47		
Middle	140	11		
Superior	71	5		
Occupation: ⁴				
Field worker	128	12	1.07 (0.68- 1.66) ⁵	
Services and sales	132	7		
Managers and professionals	56	3		
Workers in Factory, Construction, Mechanics, craftsman	139	6		
Student	139	13		
Housework	587	42		
¹ OR calculated for each 10 years. ² Hypothetical risk group: Poverty and Extreme poverty (1) ³ SL recorded in 1238 older than 10 years; Risk group: None or elementary (1) ⁴ Occupation according to the ISCO (see reference) in 1179 persons, including child workers ⁵ House work (585) against all other occupations				

Table 1: Demographic variables of the 1264 subjects sampled for ChD in Jalisco, Colima and Nayarit, Mexico during 2010-2011, and their association with ChD using uni and multivariate Logistic Regression.

We observed that 9.1% of the population belong to the higher SES level, while 49% to the middle class, 36.3% to the poor, and 4.9% to extreme poverty. The weighted OR and CI resulted in no significant differences between SES and ChD, even after analyzing the four strata of SES as “dummy” variables. For its part, the SL in 1214 individuals showed a percentage of people with a null school of 31%, with incomplete primary education 50%, and very few individuals with professional or higher levels (5.6%). We found a discrete nonlinear correlation between SL and SES, exclusively in people with higher education ($R^2 = 0.0216$, $p = 0.06$). SL neither showed association with ChD. Regarding the peoples’ occupation we did not find any significant correlation with ChD,

although the Homeworkers showed a slightly higher prevalence but statistically no significant.

In table 2, we observe the correlation of ChD with environmental variables. The type of settlement (rural or urban), including Guadalajara, Tepic, and Puerto Vallarta with more than 500000 inhabitants, showed no significant association. Seventy hundred eighty-two individuals have animals at home, especially pets (54.4%), although this did not show association with ChD. Concerning the quality of the dwelling, the construction characteristics with a supposed higher risk of transmission showed a slight negative relation with the prevalence of ChD, although this figure did not reach statistical significance.

Variable	Sampled people	ChD	Univariate OR (CI 95%)	Multivariate OR (CI95%)
Type of locality				
Urban	758	44	1.43 (0.92- 2.22)	1.53 (0.93- 2.53)
Rural	506	41		
Animals at home ¹				
Yes	782	57	1.43 (0.74- 2.7)	1.43 (0.73- 2.8)
No	212	11		
Housing Quality				
Meager (Ceiling and walls made of metal Clay, Palm or cardboard; Dirt floor)	50	1	0.86 (0.57 - 1.32)	0.72 (0.45- 1.17)
Medium: (Ceiling made of cement or roof tiles, walls of Adobe or masonry bricks, floor of cement or bricks)	838	58		
Good quality: (Vaults of cement, plastered walls and floor of ceramic tiles). It includes luxury residences and country houses for leisure	376	26		
Inhabitants per room				
≤ 2	834	59	0.94 (0.76- 1.16)	0.84 (0.5 - 1.43)
>3	425	26		
¹ They were recorded in 318 houses (944 inhabitants). It includes pets and warm blood. Barnyard animals No significant association nor interaction between environmental and demographic variables was obtained.				

Table 2: Environmental characteristics of settlements and houses of sampled people at the 58 localities and their association with ChD seroprevalence analyzed using Logistic Regression.

After that, we performed a multivariate analysis of the most influential variables transformed in a dichotomous fashion which results are depicted in Table III. For this analysis, we used the age group of 11 to 30 years as a reference. As we can appreciate, the interaction of young females living in rural areas and with a low SES, showed the most significant association with ChD.

Variable	Sampled	ChD	Univariate OR (CI 95%)	Multivariate OR (CI95%) ¹
Age				
11- 31	381	36	1.77- (1.13- 2.78)	2.23 (1.34- 3.72) p=0.0021
Rest	883	49		
Sex				
Male	371	18	1.6 (0.93- 2.7)	1.91 (0.95-3.86) p=0.068
Female	893	67		
Socioeconomic Status ¹				
High- Medium (0)	743	54	0.83 (0.61- 1.13)	0.77 (0.45- 1.3) p=0.32
Low and Extreme poverty (1)	521	31		
Occupation:				

Housework	587	42	1.07 (0.68- 1.66)	0.87 (0.48- 1.5) p= 0.64
All other	624	42		
Type of locality				
Urban	758	44	1.43 (0.92- 2.22)	1.7 (1.01- 2.82) p=0.045
Rural	506	41		
Animals at home ²				
Yes	782	57	1.43 (0.74- 2.7)	1.3 (0.66 - 2.56) p=0.44
No	212	11		
Interaction model ³				
Age 11- 32 years+ Female + Low SES + Rural settlement	50	9		3.28 (1.5- 7.0) p= 0.0021
All other	1214	76		
¹ Socioeconomic status showed significant Co-variability with SL and Quality of houses, so, they were removed from the Multivariate analysis. ² In 994 individuals with complete data of variables ³ After eliminating the less influential variables with the Backward Step process.				

Table 3: Analysis of interactions of the most influential variables with ChD after transforming them into dichotomous scale for a Multivariate Logistic Regression.

Discussion

The ChD prevalence found by us is consistent with previous findings in the area [8,14], and it is higher than the estimated for the national seroprevalence reported by the Mexico's Secretary of Health of 0.53/ 100,000 in 2010 [15]. This fact indicates a relevant sub-register of ChD in the Mexico's official figures.

Concerning the prevalence of ChD and demographic variables, we found a significantly higher rate in young women (aged between 11 and 30 years) living in rural settlements and with a low SES, independently from the other factors. This occurrence could depend on more intense exposure of women to infection with TC due to being at home for longer, where triatomines are colonizing with a rising frequency. Such phenomenon is similar to other observations in South America [16], and warrants further investigation since Tc infection in women, particularly of childbearing age, represents an additional challenge of public health, given the risk of congenital transmission of ChD [17].

Regarding the higher prevalence of ChD among people between 11 and 30 years old, our data contrasts sharply with former studies in South America [16], and other parts of Mexico, where authors report a median age older than 50 years [18]. We do not have a clear explanation for this higher frequency in young people; however, we can assume that prevalence of ChD in older patients is reduced because the disease produces a significant lethality after 20 years of infection [19], especially in endemic areas without access to a specific treatment, such as Mexico [20]. Therefore, we

probably do not have more old patients with ChD because of mortality and not because of a protective effect of age. Out of these findings in young female population, we did not encounter significant association of ChD with SES, SL, with rural communities, poor house quality, nor with animals at home, as is generally asserted in other regions [2-5,18]. Instead, our results are consistent with recent data on ChD in the United States, where women with the highest economic level have the highest risk of infection [17]. The distribution of SES and SL in our population are similar to the distribution of economic strata amongst Mexican society according to the AMAI [12], so we cannot attribute this finding to a SES selection bias, differing from those reports made in South America in which authors usually sampled low-income people preferably [5,16]. Our results suggests that young people, especially housewives living in recent human settlements and deforested areas, are more likely to have unnoticed contact with naturally infected triatomines present in the region, particularly *Meccus longipennis*, *T. barberi* and *M. pallidipennis* that are in a process of adaptation to human habitats [21]. Independently of meager houses or extreme poverty.

Conclusions

ChD in Western Mexico is a persistent public health problem both in urban and rural communities, which preferentially affects young women of low socioeconomic status: However, in older people, the prevalence of ChD is similar between individuals with any SES and SL level or house quality. Our results support the

proposal to retake triatomine control measures in Mexico and not consider ChD a neglected disease.

Authors' Contribution : FEG, AANS, CGB: Original idea and design of the study; MGZC,: Coordination of field work; CGB, MGZC, IDE, SPS and MSR: Performed laboratory assays; FEG: Analysis of data, Resources management; FEG, CGB, JR (jorge Rabinovich); MGZC: Discussed and wrote the paper.

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