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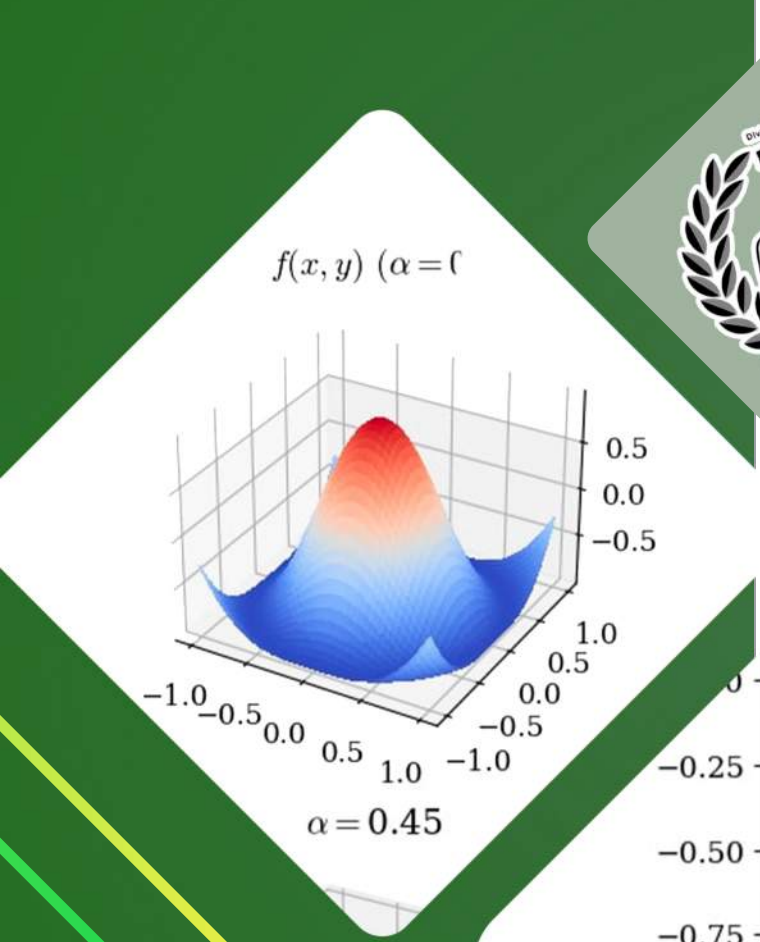

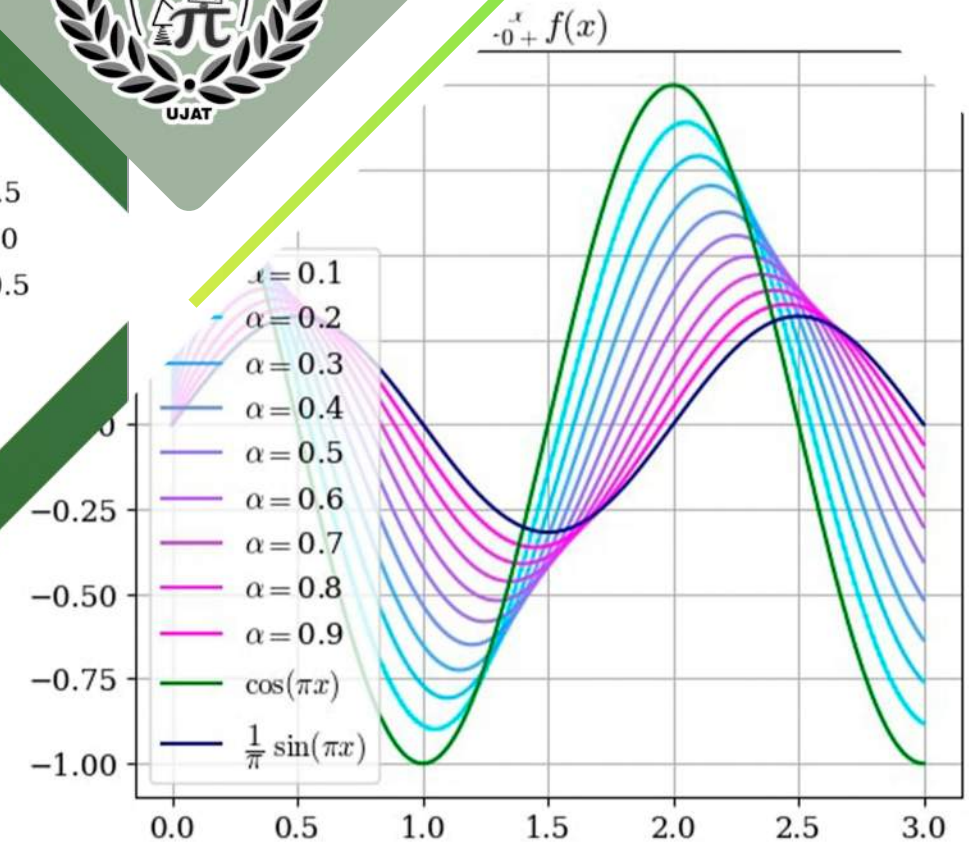

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Con el número 30 del Journal of Basic Sciences, se inicia el volumen 11 de esta revista correspondiente al año 2025. El carácter multidisciplinario de esta revista, permite enriquecer su contenido con perspectivas variadas que abordan diversas problemáticas en el área de las ciencias básicas y disciplinas afines.

De esta forma, se presenta una contribución que desarrolló generalizaciones en cálculo multivariable para llegar a nuevas diferenciales totales fraccionarias, las cuales juegan un papel importante en la modelación de gran número de fenómenos. Por otro lado, se incluye también una aportación que trata sobre el desarrollo de un método para resolver la ecuación de transporte conservativa en dominios específicos, incluyendo su validación y prueba para demostrar sus capacidades.

Se incluye además, un reporte encaminado a mejorar la calidad de imágenes, mediante técnicas de discretización numérica presentando una evaluación cualitativa y cuantitativa de los resultados obtenidos. En otro orden de ideas, se centra la atención hacia el estudio de sistemas aleatorios y la complejidad en su modelación, mostrando un estudio inferencial para un proceso de Poisson mixto, que lleva a la obtención de expresiones para densidad predictiva.

Es innegable que el aprendizaje de las matemáticas representa un reto actual que no debe soslayarse. En este sentido, se incluye un estudio que muestra la relación entre el desarrollo de la memoria de trabajo y el aprendizaje de identidades trigonométricas por parte de jóvenes del nivel medio superior, mostrando los subcomponentes necesarios en el razonamiento para el aprendizaje de este tema. En otra contribución relativa a la matemática educativa, se presenta una propuesta para atender el aprendizaje de los polígonos por estudiantes de bachillerato, mediante una serie de actividades diseñadas ex profeso que permiten una mejora en la comprensión de la temática.

En un contexto diferente, está el estudio dirigido a evaluar la actividad antibacteriana de extractos de plantas del género Cecropia, de uso tradicional en el sureste mexicano, correlacionando esta propiedad con el perfil fitoquímico analizado. Se presenta además, una contribución encaminada a analizar el impacto, que en los últimos años, han ocasionado derrames petroleros en el sureste mexicano, con especial énfasis en la afectación a cultivos agrícolas.

La atención de problemas de salud está dada a través de dos artículos que forman parte de este número. Por un lado, se comparó la resistencia a la insulina a través de índices específicos en momentos anteriores y durante la pandemia de COVID-19; en otro aporte, se analiza la relación entre diversos factores de riesgo asociados a la población joven y la enfermedad de Chagas. Mientras que en el área de la ciencia de los materiales, se incluye una propuesta para la obtención de derivados de poliuretano, con un método eficiente y compacto.

De esta forma el Journal of Basic Sciences acerca a sus lectores al amplio panorama del quehacer científico.

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Relationship between risk factors and prevalence of Chagas disease in young people in Tabasco, Mexico

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Resumen

La tripanosomiasis americana o enfermedad de Chagas es ocasionada por el parásito Trypanosoma cruzi; tiene síntomas sólo en estado crónico. Actualmente, no existen medidas de prevención temprana. El presente trabajo se centra en identificar las causas o factores de riesgo para prevenir esta enfermedad en población joven. Se aplicó una encuesta sobre factores de riesgo a una población de 517 estudiantes, se tomaron muestras de sangre para frotis sanguíneo, gota gruesa y ensayo de Hemaglutinación Indirecta (HAI). Se identificó que 52% de estudiantes tiene mascotas, 92% casa de cemento, el 4 % casa con techo de palma y 1% tiene casa de adobe. Posteriormente el 10% presentó recuento elevado de eosinófilos en frotis de sangre, y no se identificó forma parasitaria alguna en frotis de sangre y gota gruesa. Además, no se obtuvieron muestras positivas del ensayo de Hemaglutinación Indirecta (HAI), con muestras elevadas en eosinófilos y factores de riesgo. En conclusión, de 517 estudiantes encuestados, 52% tenía mascotas, 4% vivía en casas con techos de palma y 1% residía en casas de adobe. A pesar de tener contacto con mascotas o vivir en casas con techos de palma o casas de adobe hábitat, de triatominos, los frotis de sangre y gotas gruesas no mostraron la presencia de tripomastigotes. Además, ninguna de las 80 muestras de suero evaluadas en el ensayo de hemaglutinación indirecta (HAI) arrojó resultados positivos. Esto sugiere que no hay relación entre los factores de riesgo y la prevalencia de la enfermedad de Chagas en jóvenes.

Palabras claves: *Trypanosoma cruzi, enfermedad de chagas, factores de riesgo para enfermedad de Chagas.*

Abstract

American trypanosomiasis, or **Chagas disease**, is caused by the parasite *Trypanosoma cruzi* and presents symptoms only in its chronic stage. Currently, there are no early prevention measures. This study focuses on identifying the causes or risk factors to help prevent this disease in young populations. A survey on risk factors was conducted among a population of 517 students. Blood samples were taken for blood smear, thick drop, and Indirect Hemagglutination Assay (IHA). It was found that 52% of the students have pets, 92% live in cement houses, 4% in houses with palm roofs, and 1% in adobe houses. Subsequently, 10% showed elevated eosinophil counts in the blood smear, and no parasitic forms were identified in the blood smear or thick drop. In addition, no positive samples were obtained in the Indirect Hemagglutination Assay (IHA), even among those with elevated eosinophils and risk factors. In conclusion, among the 517 students surveyed, 52% had pets, 4% lived in houses with palm

roofs, and 1% resided in adobe houses. Despite contact with pets or living in houses with palm roofs or adobe walls habitats for triatomines the blood smears and thick drops, no showed presence of trypomastigotes. Furthermore, none of the 80 serum samples tested in the IHA yielded positive results. This suggests that there is no relationship between the risk factors and the prevalence of Chagas disease in young people.

Keywords: *Trypanosoma cruzi, Chagas disease, risk factors for Chagas disease.*

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1. Introduction

American trypanosomiasis or Chagas disease is a fatal disease caused by the parasite *Trypanosoma cruz*i, a flagellated protozoan found in armadillos, marsupials, rodents, bats, and wild primates, as well as in certain domestic animals, such as dogs, cats, and even rats [1], [2]. Enzootic diseases, primarily restricted to wild animals, become zoonoses when they manage to infect humans and domestic animals, integrating them into the transmission chain [3]. Triatomines thrive in environments characterized by warm and humid climates. In Mexico, there are 32 distinct species of triatomines. The detection of various vector species has revealed several transmission routes, varying depending on the state [4]. Over the past decade, the state of Tabasco, Mexico, has registered 129 transmission routes, with an average of 13 events annually, mainly in rural and marginalized areas. Only 3% of urban and peri-urban areas are in precarious conditions. Currently, this disease is recognized in 13 of the 17 municipalities of the state of Tabasco [5]. Most of the state of Tabasco (95.5%) has a warm-humid environment ideal for triatomines [6]. Likewise, industrial development in rural areas has favored the movement of triatomines towards inhabited areas, allowing them to take refuge in precarious dwellings. These conditions not only sustain their survival but also serve as reservoirs for the triatomines [7], [8].

1.1 Life cycle

T. cruzi is a protozoan, infects vertebrate and invertebrate hosts. Via a primary vector (triatomine), ingesting circulating trypomastigotes into the bloodstream of an infected mammalian host. In the mildgut of the vector, the trypomastigotes are transformed via an intermediate form known as spheromastigote, which subsequently transform into epimastigotes, which represent the main replication stage in the invertebrate host [9].

Epimastigotes migrate to the vector's upper intestine and transform into infective metacyclic trypomastigotes, which are then excreted through the vector's feces [9]. In the human host, metacyclic trypomastigotes enter through the wound generated by the itching sensation at the insect's bite site [10], [11]. Subsequently, the trypomastigotes replicate within the cell and become modified to the intracellular amastigote form. There they reproduce within 12 hours for 4 to 5 days and, finally, transform into trypomastigotes 12. Then, the host cell ruptures and the trypomastigotes are released into the circulation. The circulating parasites invade new cells to initiate new replication cycles and become available to infect vectors that feed on the host (Fig. 1) [12].

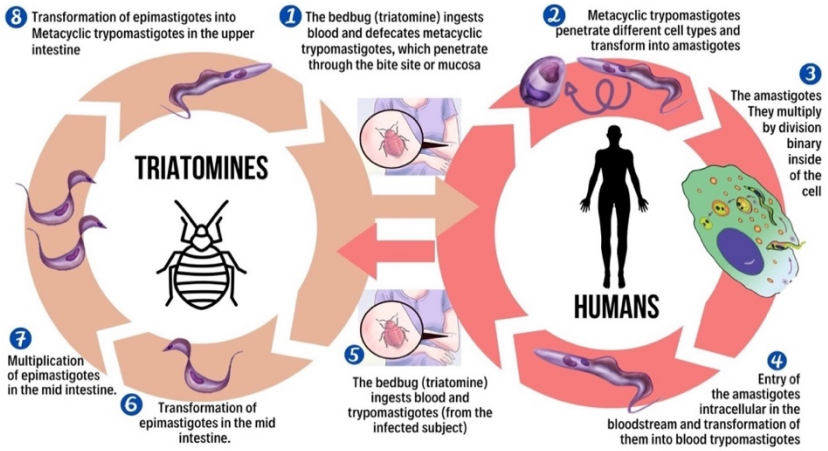


Figure 1. Life cycle of *Trypanosoma cruzi*.

In the present investigation, the risk factors related to Chagas disease in a student population from the Academic Division of Basic Sciences (DACB) at the Universidad Juárez Autónoma de Tabasco (UJAT) were identified using a survey. We evaluated the parasitic forms present in the blood using blood smears and the thick drop technique, as the stage of the disease (acute or chronic) was unknown for the students. Additionally, the indirect hemagglutination assay technique was employed to corroborate and validate our results.

2. Methods

A survey was conducted among students at DACB-UJAT. The sampling method employed was non-probabilistic, and the sample comprised 517 individuals aged between 18 and 30 years. The questionnaire was based on the knowledge on Chaga's disease and/or being affected by the disease to define the risk factors present in the households; the survey covered a total of 14 items. Personal information about the subject, housing conditions, living with animals, family history of Chagas infection, transfusions, organ transplants, and place of origin were requested (supplementary material 1).

The questionnaire had three sections. Section 1 assessed risk factors, where personal data, construction material of the dwelling were analyzed (Supplementary material 1). Clinical, epidemiological, and family data were considered to assess the subject's health status, level of exposure, and risk of Chagas disease. Section 2 corresponded to epidemiological and family data. Section 3 comprised knowledge of the disease (supplementary material 1).

The informed consent was obtained from the subjects participating in the study, in accordance with the "Ethical Principles for Medical Research Involving Human Subjects", in accordance with the principles of Declaration of Helsinki, 1964, as revised in 1975, 1983,1989,1996 and 2000, and the research protocol was reviewed by the Ethics Committee of the Universidad Juarez Autonoma de Tabasco, Mexico.

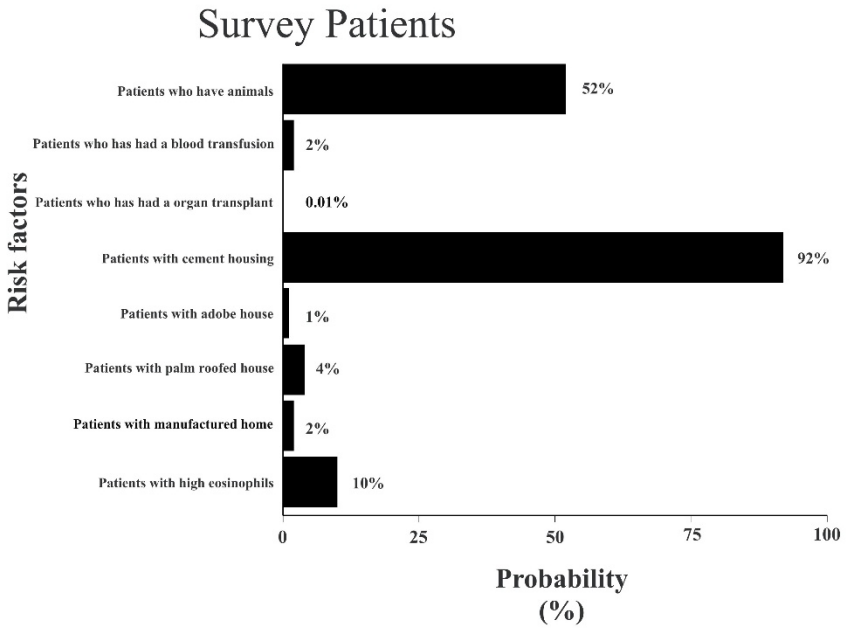
To identify the presence of the free form of the parasite, an aliquot of blood obtained by venous puncture with EDTA was taken. A smear was made using the two-slide method, allowing the sample to dry, which was fixed with 100% methanol for 5 min. Subsequently, Giemsa staining was performed, and the samples were observed under the light microscope at 40X and 100X. The thick drop smear was conducted to assess the presence of the intracellular form of the parasite (trypomastigote), spread in a circular fashion from the

corner of the slide to cause cell lysis. To identify antibodies (Ac) against *T. cruzi*, an aliquot of serum was taken. The Wiener Chaga test HAI test was used. The kit provides positive and negative controls, sensitized erythrocytes; and U-bottom polycubes not provided, Chaga test HAI, 1293205, Wiener lab.

This test is used to verify the presence of Ac against *T. cruzi* in the subject's serum that reacted with the antigen (Ag) (freeze-dried ram red blood cells sensitized with cytoplasmic antigens of *T. cruzi*), using indirect hemagglutination, considering that proteins adsorb on the surface of ram red blood cells, which act as carriers for the Ag. If antibodies against *T. cruzi* are present in the serum, and mantle, corresponding to hemagglutination, will be formed; if they are not present, the red blood cells precipitate.

3. Results

The average age of the subjects was 18 years, and they were grouped according to the risk factors to which they were exposed. Most of the subjects had more than one risk factor, thus, each subject was considered in the corresponding group. The results showed that 92% of the analyzed subjects lived in a house made of concrete, 52% lived with animals, 4% lived in a house with a palm roof, 1% in an adobe house, 2% have manufactured house and of the latter, 0.01% had received transplants or transfusions, and 2% blood transfusion (Graph 1).



Graph. 1. It shows the percentage of young people who presented risk factors out of the total of 517.

The thick drop test did not reveal the presence of circulating trypomastigote in the blood, considering that this test allows to detect the parasites in their intracellular form. Blood smears allowed to select 54 subjects (10.45%), who showed eosinophil content in their differential analysis. Among them, 10.06% displayed a content exceeding the reference value of > 4. Only 0.39% demonstrated a concentration within the normal range (0-4%), while most of the population (89.55%) exhibited no eosinophil content.

The Chagas HAI test was used to assess 80 patients selected based on their exposure to risk factors and those who had previously exhibited elevated eosinophil levels. In all the samples and the negative control, a negative reaction was observed as a ring-shaped sediment. While a positive test should have exhibited

hemagglutination, this was only observed in the positive control provided by the test kit, figure 2. Notably, no antibodies to *T. cruzi* were detected in any of the examined subjects.

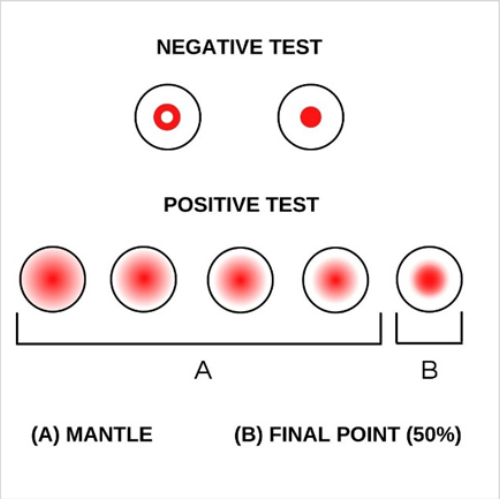


Figure 2. Show the interpretation of the Wiener Chaga test indirect hemagglutination test, in positive and/or negative cases.

In the contingency Table 1, a conditional probability calculation was performed for each of the risk factors analyzed. For the people that met any of the risk factors analyzed, a 0% probability of having Chagas disease occurred. The statistical analysis was performed, using Excel software, with the data obtained from the survey and blood tests, applying the calculation of the conditional probability for each of the risk factors considered in the study.

Table 1. Contingency table to analyze the risk factors by presenting Chagas disease.

Probably of having Chagas Disease		Chagas (+)	Chagas (-)	Total
Patient with high eosinophils	High eosinophils	(1*10^-1(0)	0.1	0.1
	No high eosinophils	(9*10^-1(0)	0.9	0.9
	Total	0	1	1
Patient with palm-roofed house	Adobe house	(3.8*10^-2(0)	3.80E-02	3.80E-02
	No adobe house	(9.6*10^-1(0)	9.60E-01	9.60E-01
	Total	0	1	1
Patients with cement house	Cement housing	(7*10^-3(0)	7.00E-03	7.00E-03
	No cement housing	(9.93*10^-3(0)	9.03E-01	9.03E-01
	Total	0	1	1
Patient with manufactured home	Manufactured home	0.03*0	0.93	0.93
	No manufactured home	0.97*0	0.07	0.07
	Total	0	1	1
Patient who have animals	Have animals	0.52*0	0.52	0.52
	Don`t have animals	0.48*0	0.48	0.48
	Total	0	1	1
Patients who has had a blood transfusion	Blood transfusion	0.02*0	0.02	0.02
	No blood transfusion	0.98*0	0.98	0.98
	Total	0	1	1
Patient who has had on organ transplant	Organ transplant	0.01*0	0.01	0.01
	No organ transplant	0.99*0	0.99	0.99
	Total	0	1	1

The following equation (Eq. 1) was applied to data treatment, as well as to the contingency table (Table 1).

$$P = \frac{P(A \cap B)}{P(B)} \qquad \text{(Eq. 1).}$$

4. Discussion

In America, Chagas disease is one of the 14 diseases of backwardness listed by the WHO [16, 17]. However, the increase in the number of positive cases in recent years, along the favorable environmental conditions of habitat for the triatomine species, and the permanent damage caused by *T. cruzi,* have prompted the evaluation of risk factors that are strongly implicated in the development of the disease [1].

Currently there is little information about the potential risk of acquiring *T. cruzi* infection. In this sense, promoting early prevention through knowledge of risk factors would prevent the patient from reaching the acute or chronic phase of the disease. Considering that Chagas disease is asymptomatic in the early stages
The risk factors on living conditions observed among the participants were: 4% had palm roofs, 1% had adobe house, at least 8% had non-concrete houses, 48% had no animals, 98% had not received any blood transfusion, and only 0.01% had received an organ transplant. It should be noted that these data indicated vulnerable subjects. However, Chagas disease was not confirmed in any of them. Despite 52% of participants showed cohabitation with animals, none of them exhibited positive results for parasitosis. Reyes, et al., in 2002, showed a 50% seroprevalence in dogs and of 20% in peridomestic animals [15], [16]. However, no further studies were performed to corroborate the presence of the disease.

Our study demonstrates that the absence of *T. cruzi* in individuals cohabiting with animals indicates that home infestation is not influenced by the presence of animals but rather by the hygienic and environmental conditions of the surroundings. The results of this study showed a lack of knowledge regarding the risk factors that lead to the existence of the disease in patients. Avila, in 1998, revealed the low level of knowledge in this regard in people from rural areas [17].
The immunological status of the subjects at this age was excellent in most, and its important underlying that in this age not studies had been realized, however, it could be convenient in the future to include more blocks of subjects of different ages.
This is important because, the chronic phase can occur up to 20 to 30 years after infection; in this period, the parasites become internalized in the tissues, mainly in the cardiac and digestive muscle, causing severe affectations and even death [11], [18], [19].
The findings related to lifestyle-related factors did not show significant prevalence, so the subjects' health level was evaluated, considering the concentration of eosinophils, a value that is linked to parasitic helminth infections when it is elevated [24]. Therefore, the blood smear was evaluated to confirm or rule out whether there was an association between the *T. cruzi* parasite and elevated eosinophils that would allow us to select positive samples.

The history of each participant was also analyzed to confirm or rule out any surgical procedure (transplant) and/or blood transfusion that could increase the risk of infection. According to Mexican regulations (NOM-253-SSA1-2012), all units of collected blood must be typed with the serological test against Chagas disease in a mandatory manner regardless of the type of procedure. This is essential for detecting markers of infectious agents transmissible through transfusion [19], [20].

In addition to the blood smear, the thick drop test was used to confirm the presence or absence of intracellular parasites [8], [21], [22]. The HAI serological method allowed evaluate the presence or absence of circulating antibodies in the serum of subjects against *T. cruzi* [8]. This test was used because it has a specificity of 95-98% and because it reveals the absence or presence in positive case of antibodies against *T. cruzi*, it was not necessary to use another type of confirmatory test [23], [24]. All blood samples selected confirmed the absence of *T. cruzi* parasites in the tested student population.

The calculation of the conditional probability allowed us to estimate how certain the assertion is that an event might take place; this value was used given that the data obtained in the survey were qualitative. Hence, our research sought to predict the percentage of risk that could compromise the subjects to generate a percentage estimate of the outcomes according to the level of exposure to each of the risk factors.

By corroborating this information with the tests performed, we obtained that the probability of undergoing Chagas disease was "0%" as well as the incidence level.

Based on the obtained results and existing literature, we believe that the timely detection of risk factors and early treatment would prevent the disease in 100% of the population [25]. Accordingly, we recommend the timely detection of risk factors., should be detected in a timely manner.

Expanding the number of subjects involved, as well as the different age ranges would allow in the future to evaluate the risk factors involved. This will help to prevent the disease and develop an adequate therapeutic follow-up to prevent reaching the chronic stage. Additionally, improving the quality of housing would control the domiciliary transmission of Chagas disease.

The relevance of our study lies in the type of data that were included to evaluate the risk factors and the tests used that allowed detecting the parasite in blood. The serological test confirmed our results and allowed us to demonstrate the presence or absence of the disease. Finally, given the diversity of triatomine species existing in Mexico, it is necessary to carry out more studies of this type to help prevent Chagas disease. This will help prevent patients from being diagnosed in chronic stages of the disease, when it is no longer feasible to find timely treatment[25]. The contribution of the results obtained in this study will allow the development of programs focused on the prevention and diagnosis of Chagas disease for the benefit of the population.

5. Conclusion

Chagas disease is a silent illness that can lead to the patient’s death if not detected in time. It is caused by the intracellular parasite *Trypanosoma cruzi*.

Tabasco has a 95.5% warm-humid climate and is rich in flora and fauna, which creates favorable conditions for the survival of Triatomines**,** the vectors that transmit *Trypomastigotes* from an infected animal to another or to humans. In this context, the present research focused on studying the risk factors that could be important for the timely detection of parasitic forms that infect humans, thereby enabling the prevention of Chagas disease at an early stage.

The survey conducted on 517 patients showed that 52% had pets**,** 92% lived in cement houses**,** 4% lived in houses with palm roofs**,** 1% lived in adobe houses**,** 2% had manufactured homes**,** 0.01% had received transplants**,** and 2% had received blood transfusions**.**

Regarding the exploration of parasites in the blood, the thick drop test did not reveal the presence of **t**rypomastigotes. It is worth mentioning that this test was performed because we did not know the stage the patients were in at the time of sampling.

The blood smear allowed for the selection of 54 patients, representing 10.45%**,** who showed the presence of eosinophils in their differential analysis. Of these, 10.06% showed eosinophil levels higher than the reference value (>4%), only 0.36% had a concentration within the normal range (0-4%), and 89.55% showed no eosinophil content.

On the other hand, a total of 80 patients were also selected, those with significant exposure to risk factors and those with elevated eosinophil levels. The sera from these patients were subjected to the Chagas HAI Test. The indirect hemagglutination reaction was only observed in the positive control but not in the patients' sera, where only the precipitation of erythrocytes was observed, corresponding to a negative reaction, similar to that of the negative control.

Subsequently**,** Equation 1 was used to construct the contingency table with each of the analyzed risk factors to evaluate the conditional probability, which predicts the risk of developing or not developing the disease. The most significant risk factor was living with companion animals; however, it was not determinant for presenting Chagas disease. The fact that 92% of patients lived in cement houses reduced the risk of contact with triatomines and, consequently, the likelihood of contracting the disease.

On the other hand, the 4% of patients who lived in houses with palm roofs, where triatomines could potentially live, was also not a determining factor for developing the disease. The age of the surveyed patients was important in our study because, at the age range of 18 years, the immune system is very active. As a result, even if risk factors are present, the immune system's activity limits the occurrence of Chagas disease. A broader age range could help establish a stronger relationship between risk factors and the prevalence of Chagas disease in Tabasco in the future.

Conflicts of interest

"The author(s) declare(s) that there is no conflict of interest regarding the publication of this article".

Declaration of the use of artificial intelligence

The authors declare that they have not used any software application, web pages of generative artificial intelligence in the writing of the manuscript, in the design of tables and figures, nor in the analysis and interpretation of the data.

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Supplementary materials

Annex 1. Questionnaire for the determination of risk factors in a young population. (Modified from [26]).

Graphical abstract

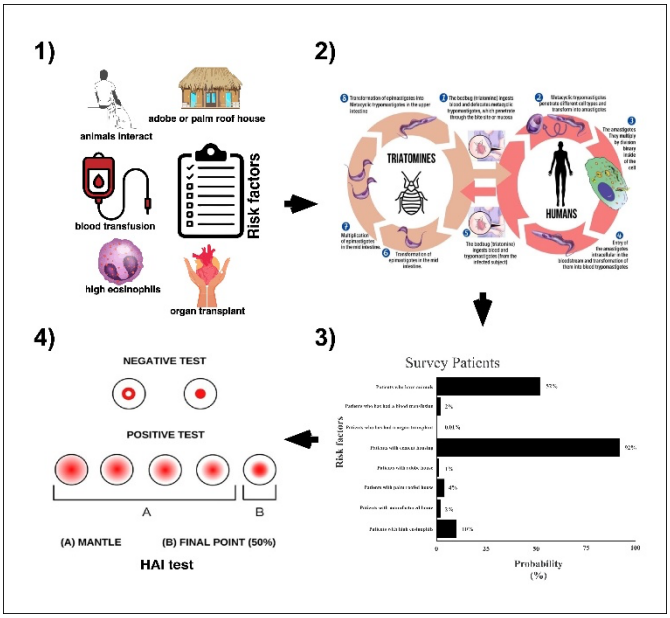

Figure 3. 1) Questionnaire for the determination of risk factors in young population, **2)** biological cycle that show the infectives forms at the vector and humans **3)** Graphics that show the percentage of risk factors in patients 4) Indirect Hemagglutinations Assay realized with serum of patients that confirm the non-existence of antibodies versus *Trypanosoma cruzi.*

6. References

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