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Health-related quality-of-life associated with Chagas disease in Argentina and Spain

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ABSTRACT

Objectives: Evidence on health-related quality of life (HRQoL) in Chagas disease is essential for understanding its burden and informing interventions. However, studies on HRQoL variation during disease progression and treatment are limited. This study provides new estimates of perceived HRQoL levels among individuals with *T.cruzi* infection, patients with Chagas disease, and at-risk populations, using a preference-based measure relevant for economic evaluations.
Methods: HRQoL data were collected from 1383 individuals in Argentina and 157 in Spain using the EQ-5D-3L questionnaire. We estimated utility scores and examined clinical subgroups, adjusting for sociodemographic factors. Overall HRQoL determinants were analyzed with truncated inflated beta regression models; domain-specific determinants with seemingly unrelated ordered probit models.
Results: Chagas disease significantly reduces HRQoL, with lower scores among older individuals and women. Chronic cardiac disease and symptoms were key determinants. Higher HRQoL was linked to being male, more educated, and asymptomatic. Urban residents, particularly in San Juan, Argentina, reported lower HRQoL. In Spain, HRQoL declined by 0.01 per month during treatment, likely due to side effects.
Conclusion: This first large EQ-5D-3L study on Chagas disease in endemic and non-endemic settings enables QALY estimation and can inform economic evaluations to guide healthcare priorities.

Introduction

Caused by infection with the *Trypanosoma cruzi* (*T.cruzi*) parasite and mainly transmitted to humans by a hematophagous triatomine vector in endemic areas, Chagas disease (CD) is one of the 20 neglected tropical diseases recognized by the World Health Organization [1]. Worldwide, 70 million people are at risk of infection, and at least 6-8 million people are infected by the parasite. However, data from seroprevalence studies suggest that the true burden of the disease may be underestimated [2]. CD is endemic in 21 Latin American countries, where the majority of the infected and at-risk population typically live in poor and marginalized areas with low access to prevention, diagnosis, and treatment of the infection [3]. Argentina, Bolivia, Brazil, Chile, Paraguay, and Venezuela contribute to most of the CD burden worldwide, with

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Bolivia recording the highest rate of registered deaths due to CD, reaching almost five deaths per 100,000 individuals [4].

In Argentina, a high burden of CD can be observed in rural areas such as the Gran Chaco region, where *T.cruzi* seroprevalence has been reported to range between 20% and 50% in previous studies [5]. Prevention of *T.cruzi* infection in this region has relied on effective fumigation campaigns and routine screening of donors in blood banks. However, deficiencies in the fumigation campaigns and a discontinuation of the surveillance system have favored the persistence and re-emergence of the transmission of the infection [6]. *T.cruzi* infections have also been reported in urban areas (known as "urban triatomism"), such as in the province of San Juan, in the Cuyo region in west Argentina [7]. Because of the migration flows from Latin America, CD has become a public health threat also in 23 countries in non-endemic areas, including the United States, Europe, and the Western Pacific region [8–10]; for example, in Spain, the number of diagnosed cases of *T.cruzi* infection has increased dramatically in the last decade [10].

CD has an acute and a chronic phase. The acute phase lasts between 2 and 4 months and is asymptomatic in approximately 90% of individuals infected with *T.cruzi*. Although antiparasitic drugs are most effective during this early stage, their usefulness is limited by the frequent absence of symptoms. In the chronic phase, between 30% and 40% of all infected people develop cardiac, gastroenterological, neurological, or mixed complications [11]. These morbidities require continuous care, tend to progress in severity, and have the potential to impair physical functioning, affect mental health, or even cause death, all of which can negatively impact patients' overall Health-Related Quality of Life (HRQoL). Evidence indicates that individuals with CD experience lower HRQoL scores compared to healthy populations [12,13]. Key contributors to diminished physical and mental HRQoL include the presence of cardiovascular and gastrointestinal symptoms. Other factors influencing HRQoL in CD-patients include age, sex, functional class, physical activity levels, healthy habits, systolic function, and the effectiveness of medication and drug therapies [12,13]. Nevertheless, evidence on HRQoL associated with CD is scarce, and available studies have been conducted mostly in small samples in Brazil [13,14].

Understanding the HRQoL of *T.cruzi*-positive individuals is essential for assessing CD burden, guiding the establishment of research priorities, as well as the development of healthcare technologies aimed at its prevention or cure, planning care, and managing patients [15]. In the literature, a few studies have examined the HRQoL of CD-patients using different generic and disease-specific questionnaires and explored associations with socio-demographic, behavioral, and clinical characteristics [12,13]. However, commonly used tools do not provide preference-based utility scores necessary to estimate quality-adjusted life years (QALYs), a measure that combines both the quantity and quality of life lived and is extensively used in the economic evaluation of healthcare interventions and technologies [16]. With this study, we employ a preference-based HRQoL measure that can inform health economic evaluations and generate new evidence on HRQoL of *T.cruzi*-positive individuals presenting symptoms (i.e., CD-patients), of those infected but showing no symptoms (i.e., indeterminates), and of the population at risk of infection in both endemic (Argentina) and non-endemic (Spain) areas.

Methods

Between February 2020 and January 2022, we collected HRQoL data among symptomatic CD-patients, indeterminate *T.cruzi*-positive individuals, and the population at risk in different endemic areas of the Northeast and Central-west of Argentina, and in Barcelona (Spain). Given the limited available information on Chagas disease prevalence, incidence, and patients' clinical characteristics, the study was exploratory, employing a nonprobabilistic sampling strategy aiming to reflect as much variability as possible across settings, exposures, and timing of disease progression, within the available study budget. The study protocol has been previously published [17]. We used certified and culturally adapted translated versions of the EQ-5D-3L questionnaire provided by Euroqol [18], which consists of five sets of questions, each investigating a "dimension" of HRQoL: (i) mobility; (ii) self-care; (iii) usual activities; (iv) pain/discomfort; and (v) anxiety/depression. For each dimension, three levels of classification are available. The questionnaire also includes a numerical scale to self-report general health within a range from 0 to 100 (Appendix A). The questionnaire was administered by trained interviewers with expertise in CD in both Argentina and Spain.

Study areas

In Argentina, data were collected in Pampa del Indio (Libertador General San Martín Department) and Quitilipi (Quitilipi Department), two semi-rural towns in Argentina's Chaco province, in the northeast of the country, near the Paraguayan border. The third study site was San Juan, the capital city of San Juan province, which has nearly 900,000 inhabitants and lies in central-western Argentina, near the Andean range that separates the country from Chile. All three sites are *T.cruzi* endemic and allowed to represent urban and rural settings as well as different socio-economic and epidemiological conditions. In San Juan, data were collected passively through Rawson Hospital services and actively via outreach coordinated by the "René Favaloro" Training Centre to identify previously diagnosed individuals. In the province of Chaco, data collection was conducted in the municipalities of Quitilipi and Pampa del Indio using both passive (administering the questionnaire during the delivery of diagnostic test results at clinical analysis laboratories) and active strategies (identifying previously diagnosed individuals through healthcare registries or past serological surveys). HRQoL data were integrated with self-reported information on age, gender, education, and area and province of residence.

In Spain, HRQoL data were collected passively from patients attending as outpatients the International Health Service at the Hospital Clínic of Barcelona after being screened for *T.cruzi* infection, or after being treated or visited if previously diagnosed positive. The questionnaire was administered at each visit, and, during the peak COVID-19 weeks when the health facility was closed, telephonic follow-ups were conducted. Unlike in Argentina, the Spanish sample included repeated measurements for most patients. Socio-economic information on patients' age, education, and occupation was obtained from hospital databases and registries.

Data analysis

Because individuals interviewed in Spain were all immigrants from Latin American countries, for both Argentinian and Spanish samples, we converted the EQ-5D health states into utility scores using a value set estimated among a representative sample of the Argentinian population [19]. To investigate the HRQoL determinants of patients with CD (in both endemic and non-endemic areas) and of people at risk of infection (in endemic areas) we employed a generalization of the truncated inflated beta regression model, which fits mixture regression models for dependent variables that are bounded in an interval and can have truncated supports either at the top or at the bottom of the distribution [20]. To investigate the contribution of the determinants to each health domain of the EQ-5D questionnaire, we employed a seemingly unrelated ordered probit model [21]. All analyses for Argentina and Spain were conducted separately.

We investigated the contribution of belonging to different clinical subgroups, namely: (i) CD-patients with clinically relevant pathologies and morbidities; (ii) *T.cruzi*-positive individuals in the indeterminate phase; and (iii) *T.cruzi*-negative individuals at risk of infection. To isolate the contribution of the disease to HRQoL, we also controlled for sociodemographic characteristics. Predictions from the regression model were used to estimate the HRQoL for each population subgroup, adjusted for their determinants. To facilitate the interpretation of the model and show the impact of each independent variable on the HRQoL scores, we estimated the predicted marginal effects based on covariates both at their observed levels and mean values.

Because data collection overlapped with the peak periods of the SARS-CoV-2 pandemic, to account for potential temporal confounding, we conducted a robustness check including a time component (monthly fixed effects) as a covariate in the regression models. This adjustment controls for variations in perceived HRQoL that may be attributable to external factors such as COVID-19 infection, quarantine, or related public health measures [22]. Moreover, to test the hypothesis of reduction in HRQoL due to treatment-related side effects, we identified a sub-sample of CD-patients undergoing treatment in Spain and conducted an explorative panel analysis based on a random intercept multilevel model and a population-averaged panel-data model (Appendix A). All analyses were conducted using Stata 17.

Results

Argentina

Between March 2021 and January 2022, 500 individuals were interviewed in Pampa del Indio, 600 in Quitilipi, and 283 in San Juan, for a total of 1383 interviewees. Most individuals were women (73%), and 90% were younger than 60 years. The sample was balanced between rural and urban residents. More than half of the respondents had primary education levels, and approximately 10% did not attend school. Regarding CD, more than 80% of the respondents self-reported having been diagnosed with *T.cruzi* infection; about 10% reported chronic cardiac CD. Of the infected, almost 70% reported that they did not receive treatment. Approximately one out of three respondents reported at least two health problems potentially related to CD (Appendix B).

Pain/discomfort and anxiety/depression health domains had the lowest reported levels, followed by usual activities; 25% (15%) of interviewees reported experiencing at least some problems with pain/discomfort (anxiety/depression). Perceived levels of self-care and mobility were overall high among all the respondents (about 95% reported no problems). Approximately one out of four respondents reported maximum levels of HRQoL in all health domains, hence HRQoL scores equal to one. HRQoL scores were lower in the elderly population and among women (median score: 0.80 for women vs 0.85 for men); respondents with CD reported systematically lower levels of health (median score: 0.75 for positives vs 0.85 for negatives). Lower HRQoL scores were reported in the urban province of San Juan (median 0.75, with some values as low as 0.20), whereas higher scores were observed in the rural Pampa del Indio settings (Appendix B).

The results of the three models considered (described in Appendix A) are reported in Supplemental Table C1 (Appendix C). AIC and BIC values suggest that the 2-component model with truncation provides the best fit for the data (Appendix D). The inflation part of the model indicates that men are more likely than women to report perfect health; the same applies to individuals from urban areas (and in particular from the urban area of San Juan) and those who received etiological treatment for CD. By contrast, being older and having at least two health problems potentially related to CD decreases the probability of reporting full health. In the mixture of beta regressions, the main determinants are age and the presence of symptoms potentially related to CD.

The predicted marginal effects on HRQoL scores computed using the 2-component two-part Beta with truncation (Model 3), based on the level of covariates as observed and on covariates fixed at their mean values, are overall comparable (Figure 1). The most important factor affecting HRQoL score appears to be the urban or rural location of the respondents; living in San Juan (categorized almost entirely as urban) is associated with a decrease in HRQoL score of nearly 0.15 out of 1. The further distinction of more urban or rural areas of residence within each province is less impactful than the differences between provinces. Reporting to be *T.cruzi*-positive is not significantly associated with lower HRQoL scores by itself. By contrast, decreases in HRQoL are mainly due to health problems and symptoms related to CD. The utility perceived by the respondent increases by about 0.02 out of 1 if they have received CD treatment (Appendix D).

Looking at the impacts on each dimension assessed by the EQ-5D-3L questionnaire, the effects are primarily driven by the presence of two or more health issues related to CD, particularly in the dimensions of mobility (0.61 increase in the severity index, indicating a shift toward worse reported health), usual activities (+0.75), pain/discomfort (+0.72), and anxiety/depression (+0.64). The "Self-care" dimension appears unaffected by any of the factors analyzed, whereas "Mobility" and "Usual Activities" show limited associations with the presence of symptoms and potential variations across socio-economic subgroups, particularly by education level (e.g., +0.38 in the usual activities index associated with primary education compared to none). By contrast, the urban living context (e.g., San Juan compared to Quitilipi and Pampa del Indio) significantly influences the "Pain/Discomfort" dimension (+1.18 for respondents from San Juan) and "Anxiety/Depression" (+1.39), indicating a greater likelihood of reporting problems in these domains. Self-reported health issues also substantially reduce perceived health in these domains (Appendix D).

Predicted HRQoL scores for *T.cruzi*-positive individuals are lower compared to *T.cruzi*-negative individuals, although the difference is not statistically significant. Among *T.cruzi*-positive individuals, HRQoL scores are heavily influenced by health and cardiac symptoms. For example, at age 30 (60), females with no cardiac issues and less than two CD-related health conditions have an HRQoL score of 0.95 (0.88), whereas those with chronic cardiac issues and at least two related conditions score 0.88 (0.80) (Figure 2 and Appendix D). While significant month-to-month effects were observed, the estimated impacts of key HRQoL determinants remained consistent in the robustness checks accounting for interview timing (Appendix E).

Spain

In Spain, HRQoL data were collected passively between February 2020 and June 2021 from 157 patients, for a total of 421 HRQoL records. Approximately half of the patients (77) were interviewed twice, and 18% (28) three times. Approximately one out of ten patients had more than six interviews, and 12% (18) were interviewed only once. Two patients did not report full information on their HRQoL and were discarded.

Most respondents were women (82%), younger than 60 years old (90%), and with Bolivian or Spanish citizenship (Appendix B). Half of the respondents had secondary education levels, approximately 20% primary, and about 10% had a tertiary education level. Almost 90% of interviewed individuals were *T.cruzi*-positive and received treatment. Most patients were asymptomatic (68%); among CD-patients with symptoms, the majority had cardiac problems (25% of the total *T.cruzi*-positive).

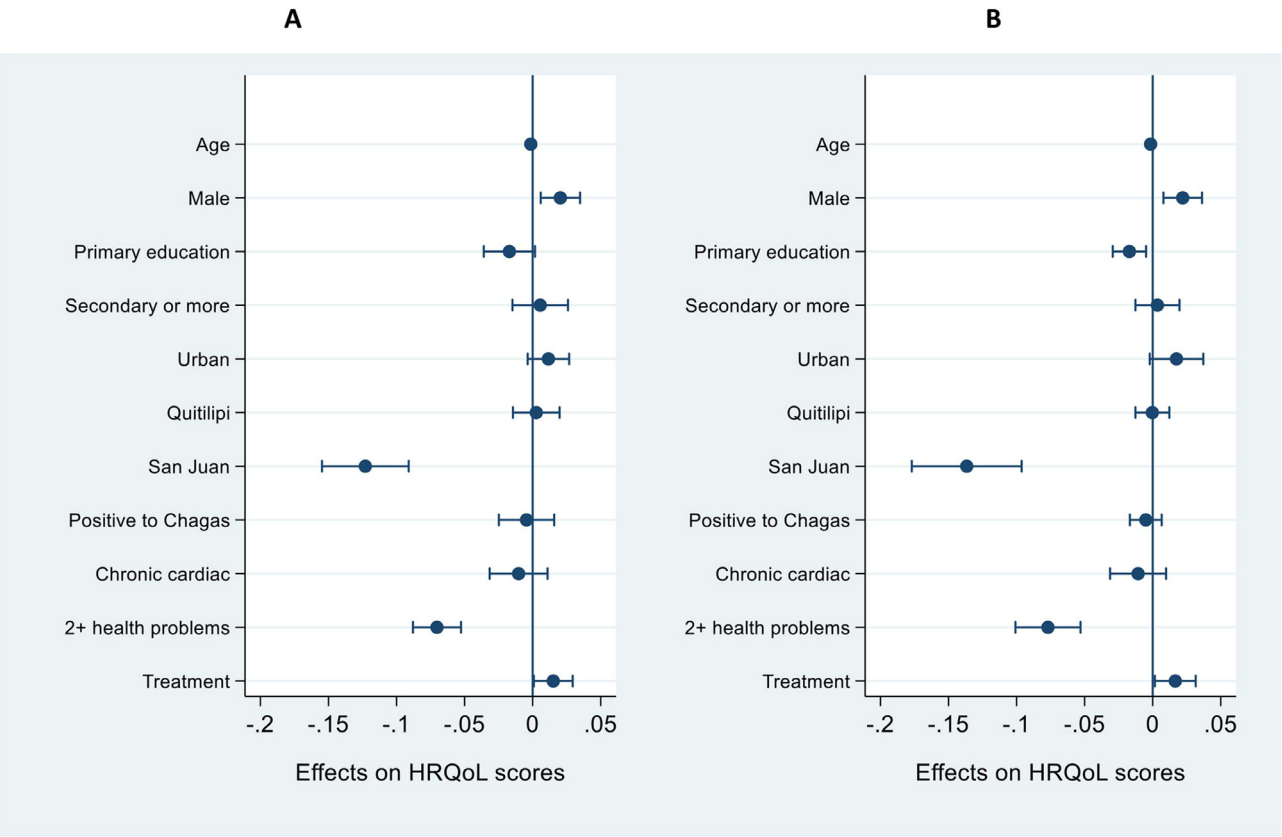

Figure 1. Average marginal effects with 95% CIs with (A) covariates as observed; (B) means of covariates (Argentina)

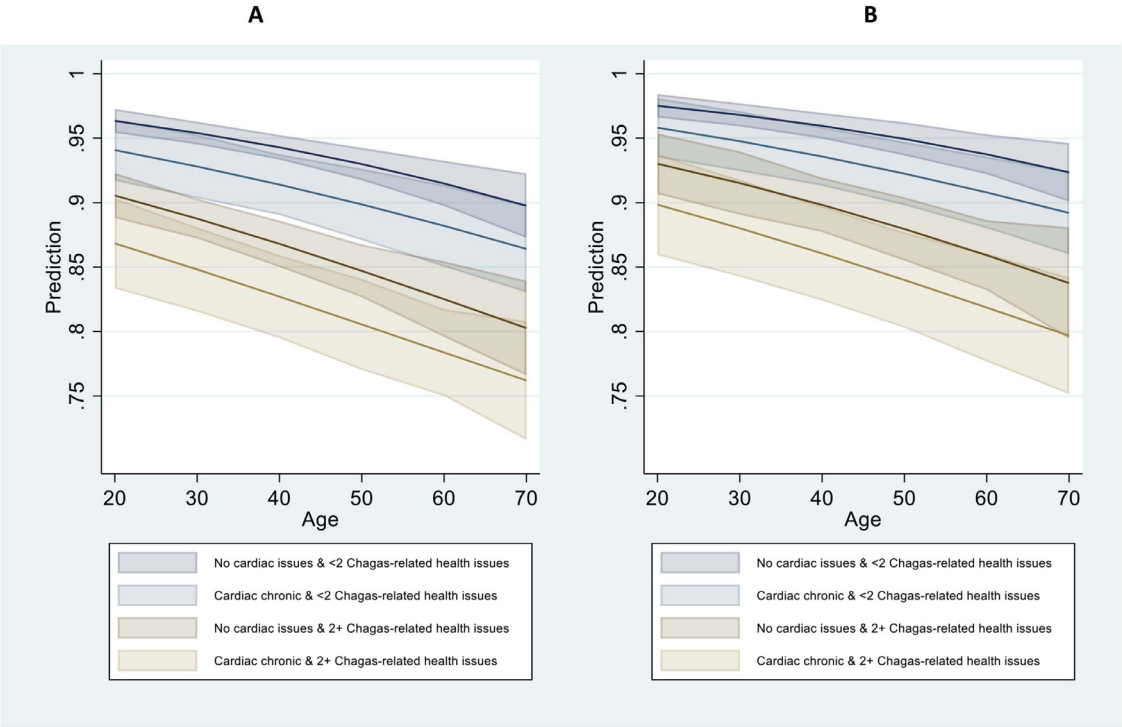

Figure 2. Predicted HRQoL for Chagas positive individuals by gender with 95%CIs; (A) females; (B) males (Argentina)

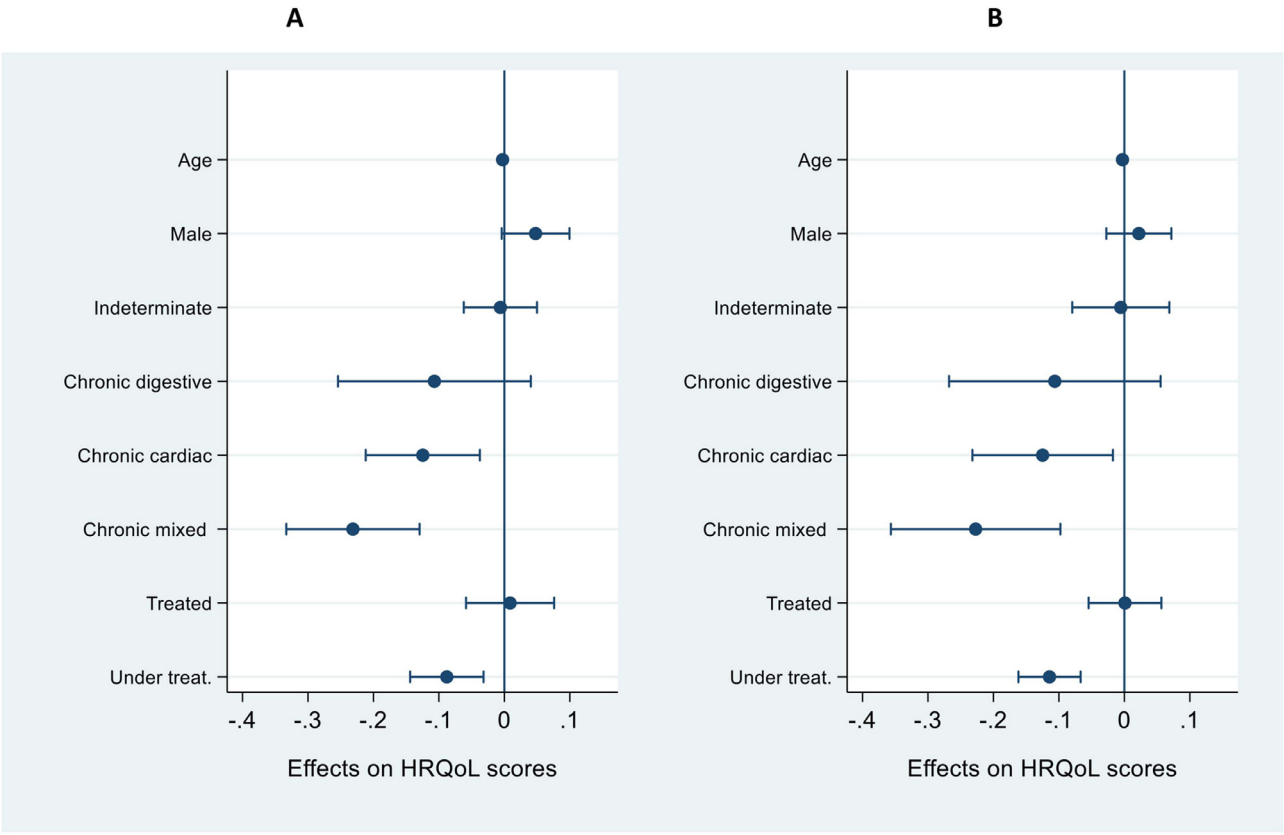

Figure 3. Average marginal effects with 95% CIs with (A) covariates as observed; (B) means of covariates (Spain)

Lowest reported levels were in pain/discomfort and anxiety/depression domains, with only respectively 41% and 60% of respondents reporting no problems in these areas. 72% reported no problems in mobility, and 75% in usual activities; self-care levels were generally high across all respondents, mostly reporting no difficulties. The distribution of HRQoL scores was skewed towards higher values, with a significant proportion of respondents reporting maximum HRQoL in all domains. HRQoL scores declined with increasing age. Women and *T.cruzi*-positive individuals reported lower levels of perceived health compared to men and *T.cruzi*-negative individuals, respectively. Symptomatic CD-patients exhibited significantly lower HRQoL, with chronic digestive, cardiac, and mixed CD-patients showing the poorest scores (Appendix B).

The results of the three models considered (described in Appendix A) are reported in Supplemental Table C2 (Appendix C). Based on AIC and BIC values, the 2-component model with truncation provided the best fit for the data. However, this model achieved marginal improvements in fit at the cost of excluding several informative variables related to CD status, only differentiating between indeterminate and symptomatic CD-patients. In contrast, the single-component two-part beta model included a richer set of regression parameters, offering better utility for understanding and interpreting the determinants of HRQoL, while still predicting values that closely matched the actual data (Appendix D). For these reasons, we selected the single-component two-part beta model.

The primary factors lowering HRQoL scores were patient age, the presence of chronic CD, and undergoing CD treatment. Men were more likely than women to report being in perfect health, while having chronic mixed CD significantly reduced the likelihood of reporting full health. The negative contribution of the various forms of chronic CD on HRQoL score was similar (digestive: 0.10, cardiac: 0.13), although the coefficient associated with chronic digestive CD was not statistically significant (Figure 3). Chronic mixed CD had the most substantial impact, reducing HRQoL by 0.23; undergoing CD treatment reduced HRQoL scores by approximately 0.09. In contrast, indeterminate *T.cruzi*-positive individuals reported health levels comparable to *T.cruzi*-negative individuals.

Across the five dimensions considered in the EQ-5D-3L, symptoms associated with CD had the most significant negative effect on perceived health levels. Chronic digestive CD had statistically significant effects on mobility (0.69, $p < 0.05$), pain/discomfort (0.87, $p < 0.01$), and anxiety/depression (0.62, $p < 0.05$). Chronic cardiac CD significantly affected all health domains, with coefficients ranging from 0.48 (pain/discomfort) to 0.79 (self-care). Chronic mixed CD showed the strongest associations, with estimated impacts of 1.72 on Mobility, 1.61 on Self-care, and 1.17 on usual activities (all $p < 0.001$). Being under treatment was associated with a lower perceived health level, particularly in mobility (0.47, $p < 0.05$); however, having completed CD treatment was linked to improved health levels (Appendix D).

For both men and women, *T.cruzi*-negative individuals were predicted to report the highest HRQoL scores among all clinical subgroups (Figure 4). Predicted HRQoL scores for indeterminate individuals varied by age, ranging from 0.90 to 0.79 for men and from 0.94 to 0.85 for women. Among chronic digestive CD patients, HRQoL scores ranged from 0.83 to 0.68 for men and from 0.86 to 0.70 for women; for chronic cardiac, 0.81-0.62 (men) and 0.86-0.68 (women); and for chronic mixed, 0.71-0.49 (men) and 0.69-0.46 (women). *T.cruzi*-positive individuals undergoing treatment exhibited lower HRQoL scores (Figure 5). Being under treatment reduced HRQoL by 0.09 to 0.17 for women and 0.07 to 0.14 for men, depending on age. On average, predicted scores for male patients under treatment ranged from 0.80 (20-year-old) to 0.58 (70-year-old), and from 0.75 (20-year-old) to 0.53 (70-year-old) for females.

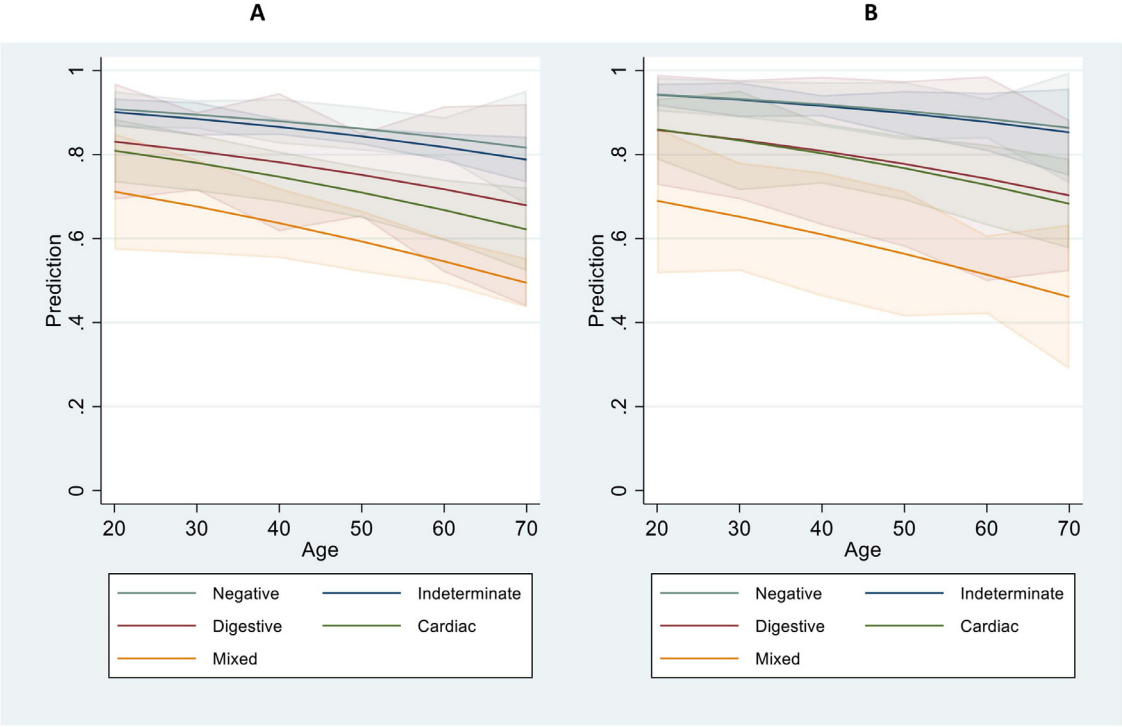

Figure 4. Predicted HRQoL for males and females with 95%CIs; (A) females; (B) males (Spain)

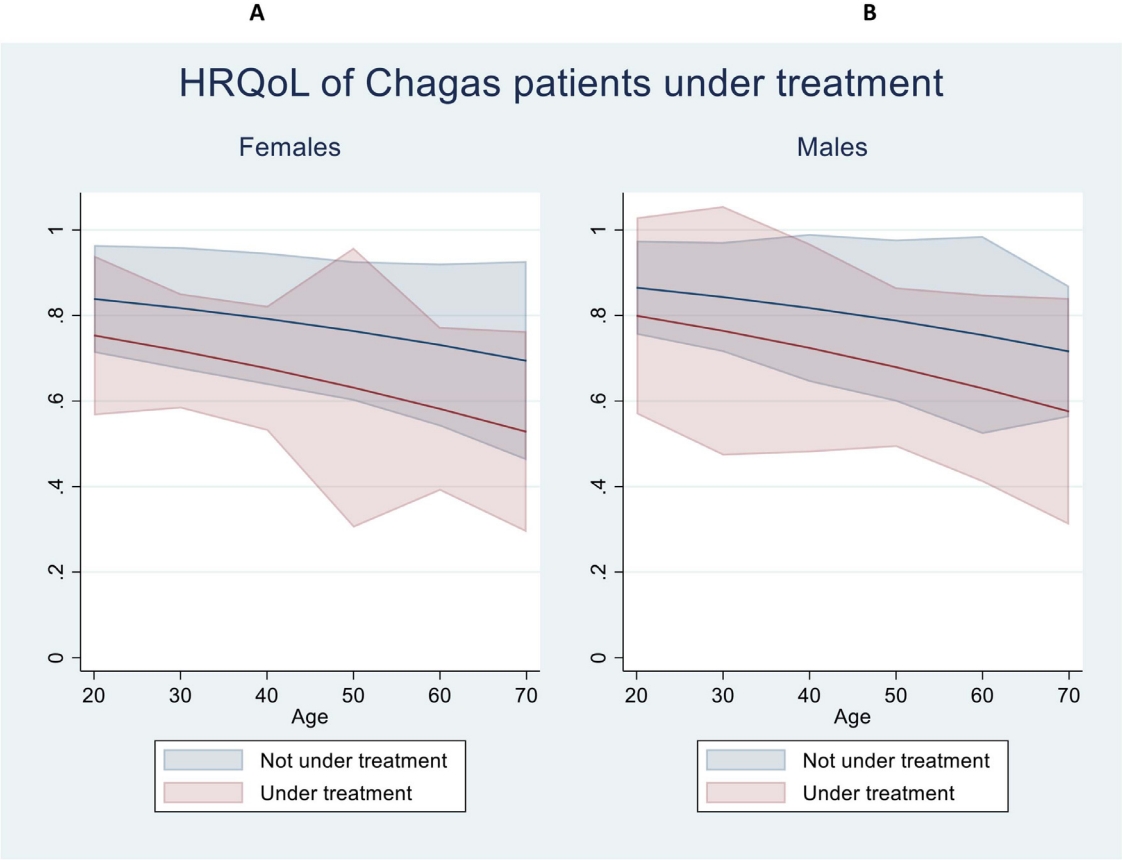

Figure 5. Predicted HRQoL for *T.cruzi*-positive individuals under etiological treatment with 95%CIs; (A) females; (B) males (Spain). Note: the wide confidence interval for men is due to the scarcity of observations. This also causes predicted values that are erroneously greater than one.

Robustness checks accounting for interview timing confirmed that the impacts of key determinants such as treatment status and symptom severity remained stable, although significant effects were observed in specific months (Appendix D). The exploratory panel analysis focusing on 20 patients undergoing treatment during the study period indicated that each additional month of treatment was associated with a short-term decline in HRQoL of approximately 0.01, likely reflecting adverse drug reactions (Appendix F).

Discussion

This is the first study assessing HRQoL using the EQ-5D-3L in a large sample of individuals affected by or at risk of CD across both endemic (Argentina) and non-endemic (Spain) settings, among diverse urban and rural populations. Perceived HRQoL was significantly reduced by CD, particularly among older individuals, women, and those with chronic cardiac symptoms. In contrast, higher HRQoL scores were associated with being male, highly educated, and asymptomatic. Our findings were consistent across Spain and Argentina, though analyses were conducted separately due to differing country contexts and study design. The Spanish sample, recruited from hospital settings, where HRQoL tends to be lower, showed a broader distribution of scores; the Argentinian sample was skewed toward higher values. HRQoL levels in San Juan were more similar to those observed in Barcelona than to those in the rural Argentinian sites (Pampa del Indio and Quitilipi), likely reflecting socioeconomic differences rather than geography alone. Consistently, rural communities reported higher HRQoL than urban ones.

Results are consistent with previous studies that have reported significantly lower HRQoL values in CD-patients compared to *T.cruzi*-negative individuals, and identified cardiovascular complications, gastrointestinal symptoms, poor functional classification, and being female as key factors contributing to worse scores [13,23]. Additionally, socioeconomic challenges and lower years of education were often associated with the disease and contributed to the lower HRQoL of CD-patients [24]. However, to date, CD studies that utilized the EQ-5D tool, the primary preference-based measure of HRQoL used in cost-effectiveness analyses, are scarce [16]. Only two small Brazilian studies found that CD negatively affects EQ-5D-3L scores, but their findings are difficult to generalize due to small sample sizes and limited representativeness [25,26]. Nevertheless, when considered alongside prior studies, our results suggest that geographic origin or migratory status does not substantially alter perceived HRQoL; instead, differences are primarily driven by age, symptoms, sex, and education.

It is well established that *T.cruzi*-positive patients undergoing treatment experience a significant reduction in HRQoL during the period of treatment, mainly due to the frequent and severe side effects of the two effective drugs against *T.cruzi* (nifurtimox and benznidazole), often leading to treatment discontinuation [27]. Similarly, we found that every additional month of treatment was associated with a HRQoL decline of about 0.01. Even if based only on a small sub-sample of 20 patients in Spain, this finding confirms the need to improve the antiparasitic treatment. New drugs with lower side effects may not only improve patients' HRQoL, but also reduce treatment dropouts.

While the multisite design allowed us to capture substantial heterogeneity in HRQoL across diverse clinical, geographic, and socioeconomic contexts, the study was exploratory and relied on a nonprobabilistic sample, with questionnaires administered at different stages of the disease. These factors limit the generalizability of the findings across settings and patient subgroups. We also acknowledge the potential limitations of conducting an HRQoL study during the COVID-19 pandemic. However, our robustness checks showed that while temporal factors contributed to variation in HRQoL, potentially reflecting pandemic-related effects, the estimated impacts of key covariates remained stable, supporting the validity of our main findings. Moreover, a non-parametric regression suggested the presence of an overall constant trend in the HRQoL of the patients, unaffected by the different waves of the pandemic (Appendix E). In Argentina, site-specific characteristics may limit generalizability: many respondents in Quitilipi were pregnant women, and Pampa del Indio includes a high proportion of Indigenous individuals. Moreover, the use of interviewer-administered questionnaires may have introduced some social desirability bias, particularly among low-SES groups. In Spain, repeated measurements of health status were collected from the same patients over time. Given the limited number of follow-up observations and the highly unbalanced structure of the panel, we treated the data analytically as pooled repeated observations, assuming that observations from the same individuals were independent but shared the same characteristics. However, to account for intra-individual correlation, we used regression models with clustered standard errors at the patient level.

Conclusion

This is the first study to employ the EQ-5D-3L questionnaire to provide detailed information on the HRQoL of a large sample of CD-patients, indeterminate *T.cruzi*-positive individuals, and of *T.cruzi*-negative individuals at risk of infection in both Argentina and Spain. We found that CD significantly reduces perceived HRQoL, particularly in individuals with chronic cardiac or mixed complications, with predicted scores ranging from 0.88 for younger, asymptomatic patients to as low as 0.49 for older, symptomatic individuals with chronic mixed conditions. In Argentina, urban residents reported HRQoL scores that were, on average, 0.15 points lower compared to those in rural areas. In Spain, patients undergoing treatment experienced an average HRQoL reduction of 0.09 to 0.17, depending on age and gender, primarily due to the side effects of current therapies.

While the study sample may not fully represent the characteristics of all populations at risk or affected by CD, and despite limitations such as the reliance on self-reported clinical data, particularly in Argentina, this study contributes to quantifying the contribution of CD on perceived HRQoL and enables the estimation of QALYs for patients at different stages of the disease. The evidence provided has the potential to inform and refine economic evaluations of research and intervention policies, and support the implementation of healthcare technologies targeting CD in both endemic and non-endemic areas [28,29].

Ethical approval

This study was approved by the Ethics Committee of the Ministry of Public Health of San Juan, the Facultad de Ciencias Exactas y Naturales y Agrimensura de la Universidad Nacional del Nordeste in Argentina, and the Ethics Committee of the Hospital Clínic de Barcelona (CEIm Hospital Clínic) in Spain (HCB/2019/1018). All participants provided written informed consent prior to participation, and study withdrawal was possible at any time.

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Author contributions

E.S. conceived and designed the study. F.R. conducted data analysis and interpretation, and drafted the article. P.S. coordinated the study and data collection in Chaco province and contributed to contextual interpretation of findings. L.S. coordinated patient recruitment and data collection in San Juan. M.J.P. coordinated patient recruitment and data collection in Spain. M.S.O. contributed to data analysis and interpretation of results. C.A.G. and E.M. provided expertise on immunological and clinical aspects of Chagas disease. E.S. provided critical revision of the article. All authors reviewed and approved the final manuscript.

Declaration of competing interest

The authors have no competing interests to declare.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2025.108363.

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