Economic burden of Chagas disease in Latin American countries: a population-based cost-of-illness analysis from the RAISE study

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Summary

Background **Chagas disease (ChD) remains a public health concern in Latin America. Despite a decline in overall prevalence, the chronic symptomatic forms still impose a substantial epidemiological and economic burden. This study undertakes a comprehensive, population-based cost analysis of chronic Chagas disease (CCD) from a societal perspective in seven endemic Latin American countries for 2010 and 2023.**

Methods **A Markov model with one-year cycles and six states was employed. Direct medical and indirect costs, converted to 2024 purchasing power parity US dollars, were estimated using prevalence data from the Global Burden of Disease Study 2023. Based on a previous Brazilian Markov model, parameters were adjusted using healthcare coverage and per capita health expenditure ratios for each country, further validated by national experts.**

Findings **In 2010, Brazil (US$252 billion) and Argentina (US$164 billion) had the highest lifetime burdens. As a percentage of annual Gross Domestic Product, Bolivia (0·9%) and Argentina (0·8%) were most affected. CCD accounted for 6% of total health expenditures in both countries. Between 2010 and 2023, most countries experienced a decline in economic burden due to decreased CCD prevalence, despite an increased proportion of patients with cardiac conditions, reflecting population aging and disease progression.**

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Interpretation CCD imposes substantial economic burden across Latin American countries. Epidemiological shift to older populations with severe cardiac forms signals increased healthcare demands. Findings inform policymakers for resource allocation and tailored interventions.

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Keywords: Chronic chagas disease; Economic burden; Societal perspective; Direct medical costs; Indirect costs; Absenteeism; Markov model; Latin American countries

Introduction

Chagas disease (ChD) remains a public health concern in Latin America, with an estimated 10·2 million prevalent cases in 2023.[1] Between 2010 and 2023, prevalent cases declined by roughly 2 million,[1] largely due to improved disease control and surveillance, housing conditions, and sanitation.[2,3] Nevertheless, the disease's chronic symptomatic forms continue to pose significant clinical and economic challenges. Chronic Chagas disease (CCD) cardiomyopathy, affecting approximately 43% of patients,[4] is a key contributor to this persistent burden. Despite its substantial health and societal impact in Latin America, few analyses have quantified the economic burden of ChD in endemic areas.[5–7] In Brazil, the economic burden, including direct medical and indirect costs, reached 0·23% of Gross Domestic Product (GDP) in 2024, absorbing 11% of annual Ministry of Health expenditures.[5] For Colombia, the most recent study[6] estimated the economic burden of ChD, including direct medical and non-medical costs, as well as indirect costs related to absenteeism, presenteeism, and premature death. The results indicate a substantial total cost of US$16·4 million, of which 44% correspond to direct medical costs, 12% to direct non-medical costs, and 44% to indirect costs. On a per-patient basis, the economic burden was approximately $5290 (2024 purchasing power parity US dollars—PPP-USD). To date, Lee et al.[7] conducted the only global economic burden, estimating average annual per-patient costs in Latin America at $5749 (2024 PPP-USD), including healthcare and productivity losses.

The present study extended a previous Brazilian analysis of economic burden of chronic Chagas disease (CCD)[5] to the seven high-prevalence Latin American countries: Argentina, Bolivia, Brazil, Colombia, Mexico, Peru, and Venezuela. These countries collectively account for 91% and 88% of regional and global prevalence, respectively.[1] The methodology incorporated a new framework aligned with international protocols, enabling finer cost disaggregation and enhanced reproducibility in other countries. Data from 2010 to 2023 were compared to identify changes in the epidemiological profile due to population aging and assess their implications for future healthcare costs.

Methods

Study design and overview

This population-based cost of illness study estimated the economic burden of CCD in seven Latin American countries from a societal perspective, incorporating direct medical costs and indirect costs. To reflect the declining incidence of ChD and the aging populations, the models were simulated using country-specific prevalence data for 2010 and 2023 (Table S1) from the Global Burden of Disease Study 2023.[1] Direct medical costs included medications, outpatient and inpatient care. Indirect costs were based solely on patient absenteeism (workdays lost), with estimates sourced from published literature per clinical ChD form.[7,8] All expenses were estimated in each country's local currency and converted to the 2024 PPP-USD using a cost conversion tool.[9] This study forms part of a broader project, "The Burden of Chagas Disease in the Contemporary World: The RAISE Study". All pertinent data (File S1—File S7) are available in the GitHub repository [github.com/chagas-latin-america/chagas-latin-america-burden].

Model development

A Markov model was estimated including six mutually exclusive health states defined according to the natural history of CCD: four clinical forms (indeterminate, cardiac, digestive, and mixed) and two absorbing states (death and cure) (Figure S1). Microsimulation with a one-year cycle length was applied to a hypothetical cohort of 10,000 individuals, with each case replicated 1000 times. At the outset of the model, individuals were distributed across health states based on the age distribution of ChD prevalence among the adult population (aged 15 years and older) in each country.[1] To estimate the distribution of prevalence across the CCD clinical forms, a two-stage procedure was employed. First, a meta-analysis including several countries was used to extract data on the average age of the study

Research in context

Evidence before this study

Chagas disease (ChD) remains a neglected tropical disease with significant public health implications, particularly in Latin America. To provide a comprehensive overview of the economic burden, our team previously conducted a systematic review, which aimed to synthesize the global literature concerning economic burden of Chagas disease, encompassing both direct and indirect costs. This review involved comprehensive electronic searches in Medline (via PubMed), Lilacs (via BVS), and Embase databases, initially covering publications up to May 31, 2022, and subsequently updated to June 1, 2025. Using relevant descriptors such as "Costs and Cost Analysis," "Economics," "Cost Allocation," "Health Care Costs," "Chagas Disease," "American Trypanosomiasis," and other synonyms and alternative terms, we included both complete and partial economic analyses without language or location restrictions, ultimately identifying eighteen relevant studies. According to this systematic review, prior research has explored the economic costs associated with this disease, often focusing on specific countries or employing methodologies that did not consistently allow for comprehensive, granular analysis or direct comparability across diverse regional contexts. These earlier studies have frequently been constrained by older data or narrower scopes regarding cost components. The scarcity and heterogeneity of primary cost data across the Latin American countries have limited comprehensive multi-country assessments, making it challenging to understand the full economic burden. More recently, a comprehensive cost-of-illness study in Brazil provided a broad analysis of the chronic Chagas disease's (CCD) economic burden. This previous work adopted a societal perspective and a Markov model, incorporating up-to-date, publicly available country-specific data to estimate lifetime direct and indirect costs. The Brazilian study highlighted the significant financial impact on the country's Gross Domestic Product (GDP) and Ministry of Health budget, underscoring the importance of financial protection within its universal healthcare system.

Added value of this study

This study represents the first comprehensive assessment of the economic burden of CCD across seven endemic Latin American countries (Argentina, Bolivia, Brazil, Colombia, Mexico, Peru, and Venezuela). Altogether, these countries account for 91% and 88% of regional and global prevalence, respectively. This work forms part of a broader project, "The Burden of Chagas Disease in the Contemporary World: The RAISE Study". Our methodological framework was based on a previously developed Markov model for Brazil, which was adapted for country-specific contexts. This framework enables finer cost disaggregation, considering both direct medical and indirect costs (absenteeism), thereby allowing for reproducibility through alternative data sources. A further contribution of this paper is the modeling of individual progression probabilities to each chronic clinical form over their life course, capturing country-specific differences in the age structure of ChD patients. By comparing data from 2010 to 2023, we could consider changes in the epidemiological profile emphasizing the role of population aging in future healthcare costs. The main findings reveal a substantial and variable economic burden of chronic Chagas disease across the selected Latin American countries. As a percentage of annual GDP, Bolivia (0·9%) and Argentina (0·8%) were most affected. CCD also accounted for approximately 6% of total health expenditures in these two countries, as compared to less than 1% in Venezuela, Mexico, and Peru. Direct medical costs represented over 60% of the total burden in most countries. In contrast, indirect costs were dominant in Venezuela and Peru, reflecting the disparities in healthcare access. Per-patient annual costs also varied substantially, ranging from $5101 in Argentina to $430 in Venezuela in 2010. Between 2010 and 2023, most countries experienced a decline in economic burden due to reduced prevalence. However, the proportion of patients with cardiac conditions increased during the period, reflecting population aging and disease progression.

Implications of all the available evidence

The evidence from this study underscores that CCD imposes a substantial and heterogeneous economic burden across Latin American countries. The observed epidemiological shift towards an older population with a higher prevalence of severe cardiac forms highlights the increasing demand on healthcare systems. The comprehensive estimates provided by this study are useful for policymakers in prioritizing resource allocation and developing tailored policies to mitigate the economic consequences of ChD. The framework developed can also serve as a tool for health technology assessments and for evaluating the impact of future interventions across the region.

population and the distribution of CCD clinical forms.[4] Only the nineteen studies that reported information on all CCD forms and were based on outpatient and population-based samples were selected (File S1). A multinomial model was then estimated to jointly assess the association between age and the probability of presenting each clinical form of CCD. Second, the resulting coefficients were applied to the age structure of ChD prevalence in each country, obtaining their respective distribution among CCD forms. The confidence interval was estimated by using a bootstrap simulation with 1000 replications. This procedure allows the Markov model to capture country-specific differences in demographic profiles of ChD patients. Data on age-structure prevalence for each country were extracted from Cousin et al.[1] for 2010 and 2023 (Table S1).

The annual transition probabilities between different states were derived from multiple sources (Table S2). Transition probabilities from the cardiac, mixed, and digestive forms to death were estimated by combining the cause-specific excess mortality with the country-specific general adult mortality rate. The probability of mortality from the mixed form was determined by selecting the higher value between the cardiac and digestive forms. For individuals in the indeterminate form, the yearly likelihood of mortality was assumed equal to that of the general population. In each cycle, the general mortality rate was updated annually to reflect age progression over time using data from 2023 (Table S3). Figure S2 displays the cumulative general mortality rates by age for each country in 2023. The time horizon was 65 years because by the end of the 65 cycles nearly all individuals were expected to have died. Health outputs included quality-adjusted life years (QALYs), years of life lost (YLL) and health-related quality of life (HRQoL) losses. All outputs were estimated following the same approach as described by Andrade et.[5] Markov model was built using the TreeAge® Pro 2009 software (TreeAge Software, LLC, Williamstown, MA, USA). An example of the decision tree defined using TreeAge® is provided in File S2. The multinomial model was estimated using R statistical software (version 4·2·2; R Foundation for Statistical Computing, Vienna, Austria), with the corresponding script provided in File S3.

Cost data and estimation

The main challenge in extending the model estimated for Brazil to other Latin American countries lies in the scarcity and heterogeneity of data on costs and healthcare utilization related to ChD, as reported in a recent systematic review.[5,10] A Python script automated Google Scholar data retrieval (File S4), extracting metadata for analysis (File S5). Five researchers independently evaluated the articles (AS, PEFB, NAJ, HB and AAS). The search yielded limited, heterogeneous, and often outdated (1990s) parameters, failing to reflect current clinical practices. To address this data limitation, two sets of Markov models were estimated. The first set, a baseline model, adapted Brazilian parameters to each country under two key assumptions: 1) healthcare utilization was adjusted by country-to-Brazil coverage ratios, and 2) CCD-related health expenditures were assumed to reflect the ratio of total health expenditures per capita in each country relative to Brazil. Corresponding ratios are in Table S4. Average health expenditure ratios were calculated over the 2000–2022, except for Venezuela (2019–2022) due to data limitations. All costs parameters for Brazil are in Tables S5–S7 and for the other Latin American countries, in the File S6. Indirect costs (lost workday economic value) were calculated by dividing the GDP per capita of each country in 2022 (expressed in 2024 PPP-USD) by working days (Tables S8–S9). File S7 provides all parameters included in the baseline Markov model.

The baseline model was presented to, and validated by, one national expert on ChD in each country, except for Venezuela. Experts reviewed country-specific assumptions on healthcare coverage and costs, confirming the lack of national data to allow direct cost modeling. They suggested adjustments mainly related to access to care and availability of high-complexity cardiac procedures. Following consultations with these experts and literature review, a second set of models was estimated for Colombia, Bolivia, Peru and Venezuela to account for key specific characteristics. For Bolivia, Peru and Venezuela, the model was adjusted to consider the lack of availability of high-complexity procedures. In Colombia, given the rare reporting of the digestive form, costs were limited to diagnostic tests and absenteeism (Table 1). Although a formal Delphi or empirical calibration was not feasible, this expert validation ensured contextual relevance of model parameters.

Cost indicators included lifetime and annual estimates, reported in aggregate and on a per-patient basis. Annual costs were expressed as a percentage of total health expenditures and GDP. In the baseline model, annual costs were disaggregated for the cardiac and digestive forms by assigning all individuals to the corresponding form at the start of the Markov model. A 3% discount rate was applied to lifetime costs, consistent with international practice and recent methodological guidelines.[11] Annual per-patient costs were derived by dividing undiscounted lifetime costs by the expected number of years lived in the model. Total costs were obtained by multiplying the per-patient costs by the estimated number of individuals with ChD in each country.

Sensitivity analysis

A probabilistic sensitivity analysis was conducted for each country. The model was simulated by simultaneously varying the cost parameters, based on the standard error of the health expenditure ratios, and the transition probabilities. For the cost parameters, a gamma distribution was assumed. Uniform distributions were applied to most transition probabilities, except for the transition from the indeterminate form to cure, for which a beta distribution was assumed due to data availability (Table S10).

Ethical considerations

The study was approved by the Research Ethics Committee of the Federal University of Minas Gerais, Belo Horizonte, Brazil (Protocol number 74852723·4·0000·5149). Although a formal, pre-published Health Economic

Procedures	Bolivia	Colombia[a]	Peru	Venezuela
Digestive medicines		x		x
Surgical inpatient care for Cardiac Chagas disease				
Permanent Cardiac Peacemaker implantation				x
Cardiac defibrillator implantation without cardiac catheterization	x			x
Review of Cardiac Pacemaker without replacement				x
Heart Transplant	x		x	x
Surgical inpatient care for Digestive Chagas disease		x		x
Clinical inpatient care for Digestive Chagas disease		x		x

[a]For Colombia, adjustments refer to costs of treatment of digestive form as the notification of this form is very rare.

Table 1: **List of procedures not provided to chronic Chagas disease patients in each country for the adjusted models.**

Analysis Plan (HEAP) was not developed for this study, all methodological decisions, analytical approaches, and outcome measures were prospectively defined prior to data analysis. This study was conducted in accordance with the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) guidelines (Table S11).

Role of the funding source

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Results

Distribution of chronic Chagas disease forms

The predicted proportions of individuals in each clinical form by age, as estimated by the multinomial model

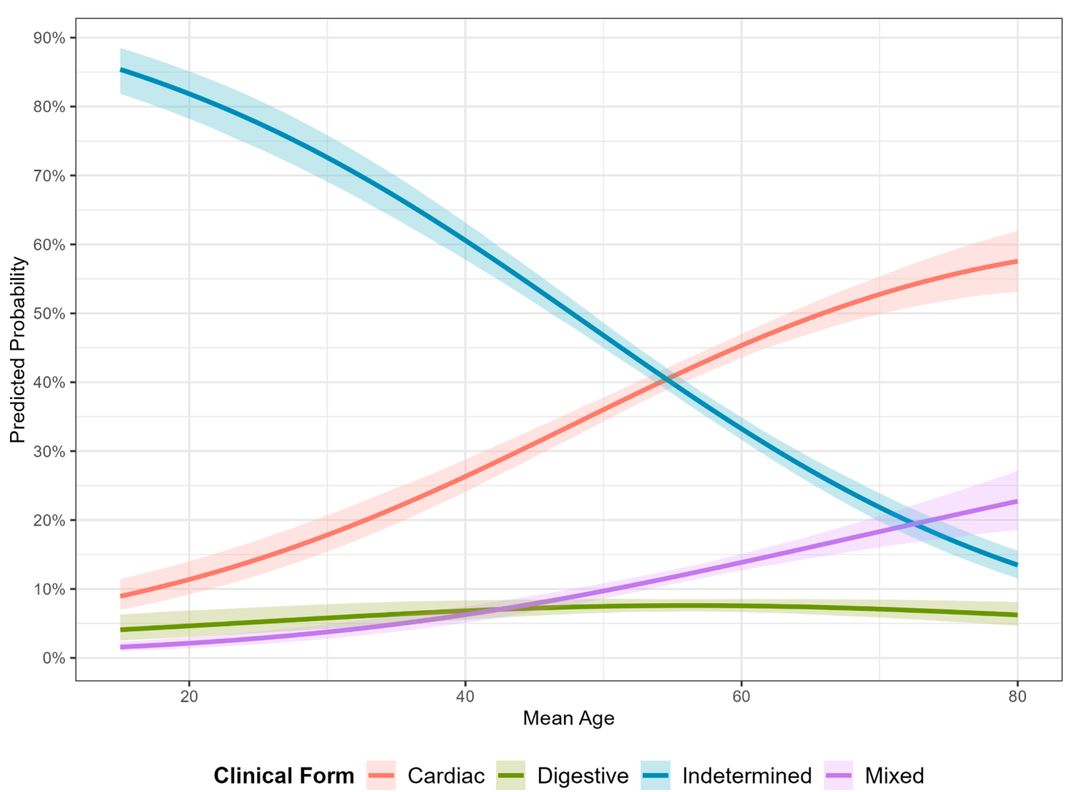

Fig. 1: **Predicted proportions of individuals in each chronic Chagas disease clinical form by age in Latin American countries—results of the multinomial model**. Note: Solid line represents the mean estimate and shaded area indicates the 95% confidence interval.

(Table S12), align with the natural progression of ChD (Fig. 1). The indeterminate form shows a negative association with age, indicating an increased likelihood of progression to more severe clinical forms as individuals grow older. The cardiac form displays the steepest age-related gradient, which diminishes after 75 years of age. The digestive form accounts for the lowest proportion of cases and remains nearly constant across the lifecycle.

The distribution of patients across the CCD clinical forms is relatively consistent across countries, with the exception of Bolivia, where a higher prevalence of the disease among younger individuals results in a greater proportion of patients in the indeterminate form reaching 56·1% in 2010. In most countries, a substantial proportion of patients are classified in the cardiac form, including the mixed form, ranging from 45% to 50%. Between 2010 and 2023, a shift from indeterminate to cardiac forms was observed, reflecting population aging and the associated progression to more severe stages of ChD (Table S13).

Costs attributed to chronic Chagas disease

Based on the baseline Markov model, the countries with the highest lifetime costs are Brazil ($252 billion) and Argentina ($164 billion), while the lowest values are observed for Venezuela ($4 billion) and Peru ($11 billion). These figures closely follow the number of cases of CCD in each country: in 2010, Brazil had the highest number (4 million individuals), followed by Argentina (2 million), whereas Mexico and Peru had the lowest, with 500,000 estimated cases each. When the annual economic burden is expressed as a percentage of GDP, Bolivia and Argentina emerge as the most affected countries, with CCD burden reaching 0·9% and 0·8% of GDP, respectively. Brazil has the third highest proportion (0·4%). The total annual economic burden as a share of national health spending ranges from approximately 6% in Bolivia and Argentina to less than 1% in Venezuela, and Mexico (Table 2).

In most countries, direct medical costs account for more than 60% of the total economic burden. However, in Venezuela and Peru, indirect costs dominate. In Venezuela, indirect costs represent nearly 90% of the total economic burden, reflecting the country's limited healthcare service coverage. A comparison between 2010 and 2023 reveals a decline in the lifetime economic burden of CCD across nearly all countries, except Mexico. This decline is associated with the reduction in the prevalence despite the higher proportion of patients with cardiac chronic conditions.

In both years, total lifetime per-patient economic burden ranged from around $6000 to $74,000, and the annual burden from $430 to $5000 in Venezuela and Argentina, respectively. The annual per-patient cost for chronic cardiac form was higher than for digestive form, ranging from $597 (Venezuela) to $8460 (Argentina) (Table 3).

Results from adjusted models, that account for country-specific particularities related to high-complexity procedures, yielded only marginal changes in the economic burden per-patient: a reduction of 4% in Colombia, 3% in Venezuela and Bolivia, and 0·1% in Peru (Tables S14–S16).

The number of expected QALY was almost 22 per individual for all countries. The years of life lost due CCD varies from 8 (Bolivia) to 10 (Colombia and Peru). The HRQoL loss is about 1 year per individual for all countries. The average patient with Chagas cardiomyopathy is expected to live around 16 years, representing a loss of 15 years compared to the scenario in which patients experience general mortality rates. For the digestive form, these figures were around 25 and 6 respectively (Table 4).

Sensitivity analysis

For Brazil, the probabilistic sensitivity analysis considers only variation in the transition probabilities. Considering the interval with the 95% of iterations, the results show that the total lifetime economic burden ranges from $197·1 billion to $251·7 billion (11% decrease and a 13% increase vs. baseline). For the other Latin American countries, the variations are higher than Brazil mainly due to the standard deviation of health expenditures ratios applied to cost parameters. The higher interval with the 95% of iterations is observed to Bolivia, ranging from $9·2 billion to $21·4 billion (35% decrease and a 51% increase vs baseline), and Colombia, from $25·4 billion to $45·6 billion (26% decrease and a 33% increase vs. baseline) (Table S17).

Discussion

To the best of our knowledge, this is the first comprehensive study to assess the economic burden of CCD, covering seven endemic Latin American countries that together account for nearly 90% of the global epidemiological burden of ChD. A recent systematic review identified only three studies estimating the economic burden of ChD.[10] Among these, Lee et al. estimated the global economic burden for 33 countries. For Latin American nations, their work relied on cost data predominantly sourced from Argentina (early 1990s) and Colombia (mid-2000s). Consequently, these historical data may not accurately reflect contemporary clinical protocols and evolving healthcare access in the region. Country-specific cost-of-illness studies have been conducted only for Colombia,[6] Ecuador,[12] and, more recently, for Brazil[5] and United States.[13] The limited availability of healthcare cost data remains a major challenge to economic evaluations. An additional barrier lies in linking available cost data, when publicly accessible, to specific diseases.

Costs outputs	Brazil	Argentina	Colombia	Peru	Mexico	Bolivia	Venezuela	Brazil	Argentina	Colombia	Peru	Mexico	Bolivia	Venezuela
	2010							2023						
Lifetime[d] (PPP-USD Billion[a])														
Economic Burden[e]	252·13	163·67	38·76	10·71	24·58	16·67	4·40	220·47	132·83	32·74	9·94	29·15	14·60	3·69
Direct Medical Costs	186·04	121·38	26·16	5·28	16·83	10·22	0·58	163·79	98·66	22·25	4·95	20·06	9·00	0·50
Indirect costs[e]	66·09	42·29	12·60	5·43	7·76	6·46	3·82	56·68	34·17	10·49	4·99	9·09	5·60	3·19
Annual (PPP-USD Billion[a])														
Economic Burden[e]	17·52	11·26	2·66	0·73	1·71	1·17	0·31	15·47	9·17	2·27	0·69	2·05	1·03	0·26
Direct Medical Costs	12·98	8·39	1·81	0·37	1·18	0·72	0·04	11·52	6·84	1·55	0·34	1·42	0·64	0·04
Indirect Costs[f]	4·54	2·88	0·86	0·37	0·53	0·45	0·27	3·95	2·33	0·72	0·34	0·63	0·39	0·23
Cardiac Economic Burden[e]	13·25	8·28	1·97	0·50	1·32	0·75	0·20	12·27	6·87	1·75	0·49	1·63	0·71	0·19
Digestive Economic Burden[e]	3·15	1·98	0·48	0·13	0·31	0·18	0·06	2·88	1·64	0·42	0·13	0·38	0·18	0·05
% GDP (Annual)[b]														
Economic Burden[e]	0·40	0·79	0·24	0·12	0·05	0·88	0·15	0·35	0·64	0·21	0·12	0·06	0·77	0·13
Direct Medical Costs	0·29	0·59	0·16	0·06	0·04	0·54	0·02	0·26	0·48	0·14	0·06	0·04	0·48	0·02
Indirect Costs[f]	0·10	0·20	0·08	0·06	0·02	0·34	0·13	0·09	0·16	0·07	0·06	0·02	0·29	0·11
% Total Health Expenditures (Annual)[c]														
Direct Medical Costs	3·20	5·97	2·16	1·02	0·65	6·44	0·44	2·84	4·87	1·85	0·96	0·78	5·35	0·38
% Economic Burden–Lifetime[d]														
Direct Medical Costs	73·79	74·16	67·49	49·32	68·4	61·27	13·19	74·29	74·27	67·96	49·79	68·81	61·66	13·59
Indirect costs[f]	26·21	25·84	32·51	50·68	31·6	38·73	86·81	25·71	25·73	32·04	50·21	31·19	38·34	86·41

[a]Costs expressed in 2024 purchasing power parity US dollars (PPP-USD). [b]Latin American countries 2022 GDP converted to 2024 PPP-USD is in Table S9. [c]Total healthcare expenditures in Latin American countries converted to 2024 PPP-USD (Table S9). [d]Lifetime estimates consider 3% discount rate. [e]Economic burden includes direct medical costs and indirect costs (absenteeism). [f]Indirect costs consider only absenteeism.

***Table 2:* Economic burden of chronic Chagas disease in seven selected Latin American countries, by cost component and country, 2010 and 2023.**

Costs outputs	Brazil	Argentina	Colombia	Peru	Mexico	Bolivia	Venezuela
2010							
Lifetime[b] (PPP-USD[a])							
Economic Burden[c]	54,472	74,119	41,151	21,711	45,935	16,948	6116
Direct Medical Costs	40,194	54,969	27,775	10,708	31,441	10,384	807
Indirect costs[d]	14,278	19,149	13,376	11,003	14,495	6564	5309
Annual (PPP-USD[a])							
Economic Burden[c]	3785	5101	2826	1487	3204	1187	430
Direct Medical Costs	2804	3799	1917	741	2205	733	58
Indirect Costs[d]	981	1302	908	746	999	453	372
Cardiac Economic Burden[c]	6128	8460	4558	2307	5183	2050	597
Digestive Economic Burden (3)	3869	5335	2944	1603	3280	1336	470
2023							
Lifetime[b] (PPP-USD[a])							
Economic Burden[c]	56,391	75,052	42,345	22,132	47,127	17,378	6265
Direct Medical Costs	41,894	55,744	28,779	11,019	32,429	10,716	852
Indirect costs[d]	14,497	19,308	13,565	11,113	14,697	6662	5414
Annual (PPP-USD[a])							
Economic Burden[c]	3956	5181	2933	1527	3311	1223	447
Direct Medical Costs	2946	3866	2001	767	2289	760	62
Indirect Costs[d]	1009	1315	931	761	1022	463	386
Cardiac Economic Burden[c]	6128	8460	4558	2307	5183	2050	597
Digestive Economic Burden[c]	3869	5335	2944	1603	3280	1336	470

[a]Costs expressed in 2024 purchasing power parity US dollars (PPP-USD. [b]Lifetime estimates consider 3% discount rate. [c]Economic burden includes direct medical costs and indirect costs (absenteeism). [d]Indirect costs consider only absenteeism.

***Table 3:* Economic burden per chronic Chagas disease patient in seven Latin American countries, 2010 and 2023.**

CCD forms	Brazil	Argentina	Bolivia	Colombia	Mexico	Peru	Venezuela
2010							
Expected Quality-Adjusted Life Years per patient with CCD							
All Forms (A)	21·8	22·2	21·7	22·2	21·6	22·4	21·2
Cardiac Form	16·2	16·3	15·7	16·4	16·1	16·4	16·0
Digestive Form	25·1	25·3	24·0	25·5	25·0	25·6	24·6
Expected Life Years per patient with CCD (without disability weights)							
All Forms (B)	22·7	23·1	22·6	23·2	22·5	23·4	22·2
Expected Quality-Adjusted Life Years per patient (assuming general population mortality rates)							
All Forms (C)	31·5	31·8	29·7	32·1	31·2	32·3	30·6
Years of Life lost and HRQoL loss due to CCD							
Years of life lost (C-A)	9·7	9·6	7·9	9·9	9·6	9·9	9·4
HRQoL loss (B-A)	1·0	0·9	0·9	1·0	0·9	1·0	1·0
2023							
Expected Quality-Adjusted Life Years per patient with CCD							
All Forms (A)	21·3	22·0	21·4	21·8	21·2	22·0	20·6
Cardiac Form	16·2	16·3	15·7	16·4	16·1	16·4	16·0
Digestive Form	25·1	25·3	24·0	25·5	25·0	25·6	24·6
Expected Life Years per patient with CCD (without disability weights)							
All Forms (B)	22·3	23·0	22·3	22·7	22·1	23·0	21·6
Expected Quality-Adjusted Life Years per patient (assuming general population mortality rates)							
All Forms (C)	31·4	31·8	29·7	32·0	31·2	32·3	30·6
Years of Life lost and HRQoL loss due to CCD							
Years of life lost (C-A)	10·1	9·7	8·2	10·3	10·0	10·2	9·9
HRQoL loss (B-A)	1·0	1·0	0·9	1·0	1·0	1·0	1·0

Note: HRQoL (Health Related Quality of Life).

Table 4: **Expected Quality-Adjusted Life Years and Expected Life years per chronic Chagas disease patient in seven Latin American countries, 2010 and 2023.**

Building on previous work for Brazil,[5] we extended a cost-measurement model based on international ChD care protocols, enabling the identification of each cost component and stage of the chronic form. Brazil benefits from publicly available health data sources that allow for detailed estimation of healthcare expenditures. This model was adapted and applied to other selected Latin American countries, where such detailed data are not readily available. The model allows for a granular costs' disaggregation, including both direct medical and indirect (productivity loss due to absenteeism) components, and ensures reproducibility using alternative data sources. A further contribution of our work is the modeling of lifetime transition probabilities across chronic disease states, reflecting country-specific demographic and epidemiological patterns. By comparing data from 2010 to 2023, we account for changes in disease profiles and highlight the growing role of population aging in shaping future healthcare costs.

Our findings show that CCD represents a substantial economic impact, with Bolivia and Argentina exhibiting the highest annual economic burden as a share of GDP, 0·88% and 0·79%, respectively, and as a share of total health spending, around 6%. In contrast, Mexico, Peru, and Venezuela reported the lowest economic burden, less than 1% of the GDP and total health expenditures.

The selected countries could be classified into three groups according to the magnitude of the annual per-patient economic costs and healthcare coverage. The first group comprises Argentina, Brazil, Mexico, and Colombia, all of which exhibit high annual per-patient costs, ranging from $2826 to $5,100, and have universal health coverage. Although universal, these health systems have substantial differences in terms of funding, coverage scope and level of fragmentation. While Brazil has a public universal system without co-payments and voluntary private insurance, Argentina and Mexico have fragmented systems combining public, social security, and private sectors, often with some co-payments, and Colombia has a mandatory insurance model aimed at universal coverage, however with co-payments.[14] In this heterogeneous scenario, Argentina had the highest per-patient cost ($5100), driven by its relatively high GDP per capita and one of the highest levels of health expenditure among Latin American countries. Both Argentina and Brazil allocate a proportion of GDP to healthcare that is comparable to the average observed among Organization for Economic Co-operation and Development countries.[15] Although Mexico and Colombia have comparable GDP per capita to Brazil, their lower relative health spending contributes to more modest annual economic burden.

The second group includes Venezuela and Peru, with annual per-patient burden of $430 and $1,487, respectively. These countries are characterized by limited healthcare coverage and low levels of health expenditures. Venezuela's public health system nominally offers universal coverage but suffers from extreme underfunding, limited access, and infrastructural collapse. Peru has a mixed system with public insurance for the poorest, but the access is uneven, services are substantially limited, and both systems face significant gaps, notably for rural and semi-urban underserved populations.[14] Venezuela, with the lowest GDP per capita among the seven countries, reported an annual burden nearly twelve times lower than that of Argentina. In Venezuela and Peru, treatment-related expenditures represent a relatively small share of overall costs, reinforcing the limited access to care. Accordingly, in both countries, indirect costs dominate the total economic burden estimates. Of note, the number of days lost was assumed constant across countries due to a lack of context-specific data, potentially underestimating absenteeism in countries with weaker healthcare system.

The third group consists solely of Bolivia, which presents an unusual healthcare profile: lower-income country with universal health coverage and a high proportion of GDP (8·43%) allocated to health. Bolivia's annual per-patient cost ($1187) was approximately half that of Brazil, reflecting differences in GDP. Despite the relatively recent introduction of a universal coverage, challenges remain in Bolivia's health system in terms of funding, infrastructure, and workforce shortage, particularly in rural areas.[16]

The figures reported in the present study are lower than those estimated for Latin America ($517) by Lee et al.,[7] but are consistent with the estimates for the United States, Canada, and Australia ($2916, updated to 2024 PPP-USD) reported by the same authors. A recent study that estimated the economic burden of ChD cardiomyopathy among Latin American immigrants living in the United States[13] found values nearly 20 times higher than those estimated for Brazil. This difference closely mirrors the gap in per capita health expenditures between the two countries.[17]

Assessing the change in the economic burden between 2010 and 2023 allowed to verify the impact of population aging on expected healthcare costs. In all countries, the estimated annual per-patient cost increased by more than 3% over this period, except for Argentina (2%). These increases are attributable to the higher prevalence of ChD severe clinical forms, particularly the cardiac form, among older age groups. In Brazil, where rapid population aging is underway, the 13-year period was associated with a five-percentage-point rise in the prevalence of the cardiac form, equivalent to an estimated additional 200,000 individuals requiring care for cardiac complications. Recent data[1] indicate a clear shift in the prevalence of ChD towards older age groups, in contrast to the decline observed among younger individuals. This likely reflects the epidemiological transition driven by improved socioeconomic and housing conditions (reducing vector transmission) and greater healthcare access, enabling more accurate diagnosis and prolonged survival of patients with severe disease.[18,19] This pattern anticipates challenges and extra expenditures to health systems, especially considering the cost increase of evolving advanced interventional therapies in recent years, with a potential impact on survival and hard outcomes.[20]

The results specific to the cardiac form of CCD highlight the differences in the economic burden across countries. While the overall annual per-patient cost in Argentina was 11·8 times higher than in Venezuela, this ratio increased to 14·1 when considering only the cardiac form. These discrepant figures suggest substantial variation in access to diagnosis, clinical monitoring, and advanced treatment for ChD within healthcare systems across Latin America.

The probabilistic sensitivity analysis incorporated the standard deviation of the ratio of per capita health expenditure between each country and Brazil, calculated over the past 20 years. Because health expenditures increased substantially and unevenly across Latin American countries during this period, the resulting variability was large, especially for Bolivia and Colombia. These wider uncertainty intervals therefore reflect historical volatility in health spending rather than instability in model assumptions. The relative ranking of countries and the main policy conclusions remained unchanged, indicating that the estimated economic burden of CCD is robust to parameter uncertainty. This highlights the need to strengthen the availability and quality of national health expenditure data to support more precise policy analyses.

Our analysis further offers insights into a potential shift in the paradigm of progression from the indeterminate to visceral forms, particularly the cardiac form. While traditional views have often suggested that the likelihood of developing cardiac involvement decreases after the age of 50,[21,22] our multinomial regression model appears to indicate continued increase in the probability of cardiac disease with advancing age. This result lends support to the argument for a reconsideration of the potential benefits of providing etiological treatment to patients over 50 years of age in the indeterminate form, notably in the absence of contraindications to antiparasitic therapy. These findings alone are not sufficient to immediately change current clinical practice, but they constitute a first step in identifying the need for further research and evidence generation focused on older age groups.

The digestive form of ChD accounts for a relatively small and stable proportion of cases across the life course and among countries. Across all analyzed countries, the prevalence of the digestive form remains approximately 6·5% and shows limited sensitivity to demographic changes. This clinical manifestation is less frequently diagnosed, in part due to the nonspecific nature of its symptoms and the lower likelihood of clinical suspicion, hindering search for medical care. Consequently, it was also less frequently reported in the studies included in the most recent meta-analysis on ChD clinical forms.[4] In most countries, individuals with positive serology are not routinely assessed for digestive complications,[23] contrasting with the relatively higher compliance with guideline-driven indications for screening for the cardiac form with a simple 12-lead ECG and echocardiography, when indicated. These findings are consistent with those reported in previous studies.[23]

Limitations

In this study, we adopted a cost-of-illness (COI) framework to estimate the disease-specific economic burden. This approach was chosen for its ability to provide a detailed decomposition of costs by clinical form and by cost components according to standardized clinical protocols. However, the COI approach has inherent limitations. By construction, it is a partial-equilibrium framework that does not capture the broader macroeconomic adjustments associated with disease. Specifically, it does not consider possible reallocations of labor and capital that occur in real economies as individuals fall ill, die, or require long-term care. Treatment costs act as a drain on GDP by diverting resources away from productive investment, while disease-related morbidity and mortality hinder human capital accumulation. These dynamic effects are better captured by macroeconomic growth models, which provide a more comprehensive assessment of the societal impact of diseases.[24,25]

Another limitation is the lack of information regarding the cost of procedures and healthcare access specifically related to ChD. Given the limited availability and high heterogeneity of primary cost data across countries, costs were approximated using the ratio of per capita health expenditure in each country compared to Brazil, where the costs are routinely and mandatorily recorded in open administrative databases. Variations in this ratio are primarily driven by differences in the scope of healthcare services provided and in the prices of health inputs, including the human resources remuneration and coverage/availability of advanced therapies. Therefore, the cross-country comparisons reflect, in part, the methodological approach adopted to estimate the relative cost of procedures. This strategy was validated by national experts in each country. Following their advices, a second set of models was developed for Colombia, Bolivia, Peru, and Venezuela to incorporate key country-specific characteristics. The results obtained from these alternative specifications remained virtually unchanged relative to the baseline model, indicating the robustness of the estimates.

Finally, although this study provides comparable estimates across countries, it was not possible to explore intranational socioeconomic or regional differences due to the lack of disaggregated data. Addressing these inequalities would be crucial, as access to healthcare services and disease outcomes are likely to vary substantially within countries.

Future directions

This framework can be applied to simulate the effects of changes in the unit costs of specific interventions or to support country-level health technology assessments, ultimately impacting the development, quality assessment and improvement of public programs for mitigating the impacts of ChD. The granular costs' disaggregation provided by COI framework is particularly useful for policy analysis, as it allows for simulating how variations in unit costs, transition probabilities, and mortality rates may influence total expenditures. It also enables the assessment of how potential changes in healthcare delivery, such as earlier diagnosis, prevention of acute events, or slower disease progression, could affect both direct and indirect costs. In this sense, this framework offers an essential analytical basis for informing economic evaluations of health technologies and for supporting decision-making in resource allocation.

Conclusion

This study encompasses a comprehensive estimation of the economic burden of CCD in Latin America using a detailed methodological framework that includes diagnostic procedures, pharmacological treatment, and other components of clinical care. This analysis builds upon a previously developed Markov model for Brazil,[5] incorporating both direct and indirect costs through a cost-of-illness approach grounded in internationally treatment protocols and real-world data. Brazil, which has the most extensive research on ChD, including cohort studies, publicly available health system data, and a highly qualified mortality information system, served as the foundation for methodological development. This approach enabled a robust estimation of disease-related expenditures from both health system and societal perspectives. This framework is able to generate comparable estimates of economic burden across Latin American countries. The model was adapted to reflect country-specific differences in health system coverage and access to care. Moreover, this study introduces a novel component by modeling the probability of individuals progressing to each chronic clinical form over the life course. This feature allows the model to capture differences in the age structure of ChD prevalence across countries, thereby improving the precision of burden estimates.

Contributors

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Data sharing statement

Upon reasonable request to the corresponding author, study data and analytical methods may be made available to other researchers for the purposes of reproducing the results or replicating the procedures of this study. All relevant data to estimate the Markov Model and the multinomial model are available through the public GitHub repository at (github.com/chagas-latin-america/chagas-latin-america-burden).

Declaration of interests

P.P. is World Heart Federation employee. Y.G. and C.D. are Novartis Pharma AG employees. This article represents the views of the authors and should not be interpreted as reflecting the views of their employers. The authors declare no further conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2025.101340.

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