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Chagas Disease and Brazil's Unified Health System (SUS): The Challenge of Confronting Historical Gaps

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Abstract

It is estimated that more than two million people are living with Chagas disease in Brazil. Although many affected people live in large cities and state capitals, a vast contingent remains dispersed across rural and sparsely populated zones, in extensive inland areas, much of it within a corridor stretching from the Northeastern semiarid region to the Southern pampas, passing through the Cerrado of Central Brazil, a region severely affected by the endemic. Outside this wide belt where vectorial transmission has been virtually interrupted, new cases continuously emerge from the sylvatic circulation of *T. cruzi* in the Amazon region. Many of affected persons, often unaware of their condition, face major difficulties in accessing adequate medical care. They move through poorly defined therapeutic itineraries, where even basic procedures such as serological testing, electrocardiograms, or echocardiograms are difficult to obtain. It is necessary to map the most vulnerable and priority areas, to incorporate CD into primary health care programs through health information systems, to expand access to electrocardiographic evaluation with telemedicine support, to ensure referral and counter-referral systems to cardiology and gastroenterology outpatient clinics, to facilitate access to echocardiography, and to identify facilities that provide high-complexity procedures. In conclusion, it is crucial to build care pathways based on the organizational principles of the SUS: universality, decentralization, equity, comprehensiveness, and hierarchization, as well as popular participation through patient associations and health councils. Upholding these principles for people affected by CD—and other cardiomyopathies—is essential not only for survival but also for ensuring dignity and hope, especially in inland communities, where more vulnerable populations depend on primary health care as the only gateway to treatment. In this article, we seek to highlight the main barriers to healthcare faced by people affected by CD, proposing a general framework for their medical care, with the aim of contributing to healthcare policies.

Keywords

SUS, Chagas disease, Access to Health Care

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The Current Landscape of Chagas disease and its Determinants in Brazil

Chagas disease (CD) is caused by *Trypanosoma cruzi* (Kinetoplastea, Trypanosomatidae), a flagellated protozoan. Clinically, an acute phase – frequently unnoticed but potentially severe, when manifesting with systemic inflammation, acute myocarditis and/or meningoencephalitis – can be followed, throughout the rest of life, by the chronic phase, with manifests by the cardiac (cardiomyopathy) and/or digestive (oesophageal or colonic motility dysfunction) forms. [1] In endemic countries, CD is a frequent cause of cardiomyopathy, heart failure and complex arrhythmias requiring specialized cardiological care. [2] Stroke, arising from left ventricular thrombi, is also a common intercurrence of CD. [3] Many CD cases (almost 60%) have a benign evolution being classified as indeterminate, without apparent heart, oesophagus or colon damage. [4-6] People with the indeterminate form require electrocardiographic follow-up, besides monitoring for the onset of dysphagia or intestinal constipation, since the disease may progress. [7]

CD transmission through the classical vector-borne route – the bite followed by immediate contact of injured skin or intact mucous membranes with the faeces of hematophagous triatomines infected with *T. cruzi* – has been virtually interrupted in Brazil, primarily due to intensive vector control campaigns based on insecticide spraying of houses carried out from the 1960s to the 2000s. [8] These campaigns focused rural areas and initially employed BHC (hexachlorocyclohexane), which was progressively replaced by synthetic pyrethroids such as deltamethrin. [9-11]

Before chemical control, several decades of intense and constant intradomicile contact between humans and *T. cruzi*-infected triatomines created a stable transmission landscape for CD, producing a great magnitude endemicity that was characterized through seroprevalence surveys performed in different Brazilian states. [12-15] The first nationwide survey, conducted between 1975 and 1980, confirmed that CD was endemic across Brazil, affecting rural populations in the Cerrado (central Brazil), in the northeastern semi-arid region (Caatinga biome), and in the southern Pampas, as well as in the Atlantic Forest and in the Amazon. [16] However, the first three biomes mentioned showed areas with higher prevalence rates in rural zones, particularly in states such as Piauí (4%), Bahia (5.4%), Sergipe (6%), Minas Gerais (8.8%), Rio Grande do Sul (8.8%), and Goiás (7.4%). [16] Amazon possibly did not present demographic conditions favourable to stable transmission by domiciliated triatomines and was therefore assigned, initially, a region with lower prevalence. [16]

Many endemic regions, including outside Brazil, shared a common feature: a land tenure structure that fostered rural misery, resulting in extremely vulnerable housing prone to colonization by triatomines —notably *Triatoma infestans*, *Panstrongylus megistus Triatoma sordida*, *Triatoma brasiliensis* and *Triatoma pseudomaculata*. [17-19] The result of such scenario is a current high burden of morbidity and mortality. Statistical modelling of data extracted from a meta-analysis of prevalence studies combined with data obtained from information systems indicates an average prevalence of 3.25% (± 2.9%), suggesting that near 3.7 million people lived with CD in Brazil in 2015-2016. [20] In another projection, national pooled prevalence ranged from 4.4% (95% CI: 2.3-8.3) in the 1980's to 2.4% (95% CI: 1.5–3.8) after 2000, suggesting that, at the beginning of the 21st century, there would be around 4.6 million people living with CD in Brazil. [21] According to the Pan American Health Organization, Latin American countries have about 7.5 million people living with CD, of whom nearly 4 million live in Brazil. Among them, 940,000 are women of childbearing age, which may result in approximately 2,500 cases of congenital Chagas disease per year. [22] In a national health survey carried out in 2019, a total of 659,774 adults aged > 18 years reported having received a medical diagnosis of CD at some point in their lives in Brazil (23).

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According to Martins-Melo, CD was identified in 122,291 deaths, corresponding to 0.54% of fatalities registered in Brazil from 2000 to 2019, generating an average annual age-adjusted mortality rate of 3.22 deaths/100,000 inhabitants. [24] From a total of 183,123 people undergoing first pacemaker implantation in Brazil from 1994-2011, 35,204 (19.2%) were due to CD. [25] CD remains one of the leading indications for heart transplantation in Brazil. In a multicentre study involving 792 transplant recipients, 14.8% were attributed to CD, ranking as the third most common cause. [26] In northeastern Brazil, an analysis of 376 heart transplants from 1997-2019 confirmed CD as the third most frequent indication. [27] In the Federal District, more than 60% of elderly patients undergoing heart transplantation had underlying CD cardiomyopathy. [28]

Despite this enormous public health burden, the majority of the current extra-Amazonian seroprevalence studies have shown the virtual absence of children and adolescents with positive serological tests in regions that once had stable classic vector transmission [29-31], being in accordance with the national survey of seroprevalence for evaluation of the control of CD in Brazil (2001-2008), which included 104,954 children in all rural areas in Brazil, except the state of Rio de Janeiro. [32]. A seroprevalence survey conducted in 2003 among 1,412 children aged 7 to 14 years living in one of the most endemic areas in the state of Minas Gerais (Jequitinhonha Valley) identified a prevalence of 0.4%. [33] Possible exceptions are represented by current studies in the northern Minas Gerais state and central Piauí state, where a handful of children with positive serology were detected. [34,35]

A particular problem in former areas of stable transmission lies in the fact that many people are unaware of their status as carriers of CD. This includes, for example, the birth cohort from the first half of the 1990s – individuals who are currently between 30 and 35 years old and, if positive in serology, would have an indication for antiparasitic treatment – which constitutes a hidden epidemiological scenario. In these regions, entomo-epidemiological surveillance needs to be constant, due to: i) Persistence of residual foci of *T. infestans*, ii) the existence of autochthonous (native) triatomine species with a high potential for colonizing homes or a recurrent history of invading the home environment, and iii) the presence of animal reservoirs for *T. cruzi* and the increasingly frequent proximity of human populations. [36-39]

A completely different scenario occurs in the Amazon region, which currently accounts for 96% (4,233 out of 4,404) of the officially reported acute CD cases in Brazil between 2008 and 2023, according to data from the Notifiable Diseases Information System (SINAN, Portuguese acronym) available at https://datasus.saude.gov.br/acesso-a-informacao/doencas-e-agravos-de-notificacao-de-2007-em-diante-sinan/. Among these cases, 3,489 occurred in the state of Pará, with 2,395 concentrated in eight municipalities: Ananindeua, Abaetetuba, Breves, Belém, Cametá, Curralinho, Barcarena, and Bagre. Another 332 cases were reported in the neighbouring state of Amapá, with which Pará state shares the Amazon River delta.

In the Amazon biome, the transmission of Chagas disease does not depend on the domiciliation of triatomines; instead, it is acquired directly from the zoonotic circulation of *T. cruzi* among sylvatic triatomines and mammals. [40] Of the acute cases reported in the Amazon region, 90.1% indicate in the notification form that the case was associated with oral *T. cruzi* transmission, while 8.3 % mention classical vector transmission. By far, the food most frequently contaminated with *T. cruzi* is *açaí*, when consumed fresh, which typically leads to localized acute CD outbreaks. [41] Importantly, any food, usually liquid, consumed in its natural state or packaged/processed in containers and grinders containing triatomines or their feces may be contaminated with *T. cruzi.* [42].

Since the diagnosis of acute CD is parasitological, the Amazon region benefits from a vast and efficient malaria diagnostic network that uses thick blood smears, considering that malaria is endemic in the region. [43] Nevertheless, as the acute phase of CD is most often asymptomatic,

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the reported cases may represent only the tip of the iceberg in terms of the actual number of incident cases. Thus, the landscape of Chagas disease in the Amazon may be largely underestimated. People living with Chagas disease have also been identified in the Upper and Middle Rio Negro region, in the context of a vector transmission cycle involving the triatomine species *Rhodnius brethesi*, influenced by the extraction of piassava, a natural habitat of this triatomine species. [44]

Another potentially hidden epidemiological situation is the occurrence of food-borne cases outside the Amazon region, with particular emphasis on the hinterlands of Brazil's Northeast region (Brazilian semiarid). Due to the lack of routine access to blood microscopy, the diagnosis of acute Chagas disease outside malaria-endemic regions is challenging. In fact, among the total number of acute Chagas disease cases reported in Brazil between 2008 and 2023, 3.6 % (n = 160) were reported in the Northeast region, with the last outbreak recorded in 2019. [45] In the Caatinga biome, although triatomine infestation is usually restricted to the peridomestic environment (chicken coops and corrals), house invasion is frequent. [31,46]

Main objectives and challenges of a care pathway for Chagas Disease in Brazil

According to the World Health Organization Roadmap for Neglected Tropical Diseases 2021–2030, one of the main goals for CD is that, by 2030, 75% of people with the infection are identified and treated. [47] Achieving this target requires expanding access to diagnosis at the Primary Health Care (PHC) level, ensuring continuous availability of benznidazole, strengthening congenital screening programs, and integrating CD care into national health information systems. [47] Overcoming challenges such as underdiagnosis, limited specialized services, and unequal access to treatment will be essential to reduce the burden of the disease. [47] CD requires lifelong clinical follow-up for those living with it, which makes it a particular infectious condition. In this sense, Brazil is privileged compared with other countries affected by the CD endemic, as its Constitution declares health to be *a right of all and a duty of the State*. This right is guaranteed through the Unified Health System (SUS, Portuguese acronym for *Sistema Único de Saúde*), [48] which represents the world's largest universal public health system, both in terms of population coverage and scope of services provided. Universality refers to free access for all, regardless of social security or tax contributions, to treatments of any cost, a right that also extends to immigrants from other countries living in Brazil. Nevertheless, there are major challenges and historical gaps in implementing care pathways for Chagas disease. Although many affected individuals have migrated to urban contexts, including larger cities and state capitals, a substantial contingent remains dispersed across rural areas, in Brazil's hinterlands. There, they probably lack the political visibility and influence necessary to shape health policies that would integrate them into structured care pathways within the SUS. [49] Apparently, Chagas disease is not part of the clinical repertoire of many professionals working in PHC, which further contributes to care gaps. Initiatives to disseminate knowledge about Chagas disease to these professionals have helped improve this situation. Currently, a 60-hour refresher course is available at UNA-SUS (Portuguese acronym for *Universidade Aberta do Sistema Único de Saúde*; Open University of the Unified Health System), focusing on Chagas disease in PHC, which already contributes to the continuing education of physicians and nurses, as can be accessed at https://www.unasus.gov.br/cursos/curso/46776.

Chagas Disease in the Context of Primary Health Care within the SUS: Decentralization

Managing Chagas Disease Care Pathways at the Local Level in Connection with the Ministry of Health. One of the central principles of the SUS is decentralization, which allocates

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responsibilities across federal, state, and municipal levels. [48] This structure was designed to bring decision-making and service delivery closer to communities, ensuring that health policies and services could be tailored to local needs while still following national guidelines. Within this framework, PHC is a cornerstone, and municipalities hold the primary responsibility for managing it, while states provide technical and logistical support. [48] Considering that PHC is the entry point to the SUS, a policy for the care of people with CD must be disseminated, starting from the Ministry of Health to municipal managers, with state-level mediation. In this sense, the experience of SUS in disseminating and monitoring actions through health information systems can serve as the foundation for structuring therapeutic pathways for CD, with the implementation of specific policies and/or programs to be operationalized in priority municipalities. A CD information system could manage patient registration, serology results, follow-up consultations, ECG and echocardiography, the stratification of clinical forms, referral and counter-referral flows for specialized outpatient care, the demand for high-complexity procedures, as well as case notifications and delivery of medications. In this regard, reference can be made to the experience represented by *Hiperdia*, a system for registering and monitoring patients with arterial hypertension and/or diabetes mellitus which was managed at the municipal level and enabled the generation of information for the regular acquisition, dispensing, and distribution of medicines. [50] Currently, a subsystem to integrate people living with CD could be based on e-SUS Primary Health Care (e-SUS APS, Portuguese acronym for *Atenção Primária à Saúde*), the Ministry of Health's platform for computerizing and qualifying records in PHC under the SUS. It generates reliable data for local management and strengthens PHC by documenting activities in Basic Health Units. [51]

Pursuing equity by prioritizing the most vulnerable areas. The stratification of municipalities is useful for identifying those that should be prioritized for the implementation of care pathways for CD. This stratification can be based on entomological indicators generated during a defined time interval, usually in the recent past, by municipal authorities, *i.e.* the *entomological history* of the communities. Entomological data follow the flow: Municipal collection → Municipal registration → State consolidation → Submission to the Ministry of Health → National analysis / control strategies. Currently, many regions apply the concept of community-based entomological surveillance through triatomine information posts (PITs, Portuguese acronym), whose data can also contribute to the local entomological history.[37] The collection of triatomines by municipal teams generates the following entomological indicators: household infestation index, peridomestic infestation index, and natural infection index (presence of *T. cruzi* in triatomines). [52] Undoubtedly, communities with a history of exposure to CD vectors, as reflected in their entomological indicators, are expected to present the highest prevalence of the disease. These indicators not only provide evidence of past and current vector presence but also serve as robust epidemiological markers of cumulative risk over time. In a survey coordinated by state authorities and based on entomological indicators previously generated, areas in each state could be mapped and targeted for the priority-driven implementation of care pathways for CD. An initiative along these lines was developed and termed TriatoScore, an entomological risk score for CD vector control and surveillance. It can be used to identify more vulnerable areas with a presumptively higher prevalence of infection, which may be prioritized for the implementation of care pathways. [53] SisVetor also represents an initiative to compile community-based entomological data to support strategic planning actions (https://sisvetor.sds.unb.br/).

Integrating Chagas Disease Testing into Existing Programs: Adapting Strategies to Local Realities. A considerable proportion of people living with CD are unaware of their status. These individuals could be under clinical follow-up, have their clinical form characterized, and receive appropriate treatment, preventing adverse outcomes. The identification of such people can only be achieved through testing programs implemented at the PHC level. The policy of testing

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without a physician's request (point-of-care testing, performed using rapid tests) implemented at the PHC level for HIV, hepatitis B and C, and syphilis is strategic because it expands access to diagnosis, promoting early detection of these infections, which allows for faster treatment initiation, improves patient quality of life, prevents the progression of diseases such as AIDS, and reduces transmission.[54] Initial experiences in promoting rapid testing for Chagas disease at the point-of-care have been hampered by the low positive predictive values of the available assays. [55] Pioneer projects are currently underway aiming to develop tests with improved performance that could be applied on a large scale in Brazil. [56] Testing without a physician's request could be carried out using conventional serology, provided there is adequate planning and a shift in perspective regarding people's right to be tested on their own initiative.

Testing for Chagas disease can be offered to PHC users already enrolled for the follow-up of various clinical conditions such as hypertension and diabetes, as well as during prenatal care, taking advantage of their presence at health units. The expansion of testing within PHC must be accompanied by counselling protocols for those with positive serology, and the system must be prepared to welcome these individuals and immediately insert them into the starting point of a care pathway. Many people living in areas where classical vector transmission occurred have relatives affected by CD or have lost family members to it, and people's perceptions of the disease vary across different Brazilian regions and may at times entail significant psychological distress. This makes it necessary for testing strategies to be adapted to local realities and to be humanized and person-centred. In the future, rapid tests with acceptable positive and negative predictive values for use in regions with differing prevalence rates, could assist the testing process in different epidemiological scenarios.

Strengthening Public Health Laboratories. In Brazil, clinical samples from PHC units are transferred to Central Public Health Laboratories (LACENs) following standardized SUS protocols to ensure safety, traceability, and diagnostic quality. [57] Standard chronic CD diagnosis relies on two serological tests based on different principles to confirm infection. LACENs employ several serological techniques for CD diagnosis, following Ministry of Health guidelines that recommend using two methods based on different principles to confirm chronic infection. [58] Testing also requires investment in initial processing, storage, and transportation of serum samples. Many municipalities are far from the LACENs located in state capitals and major cities and have very limited infrastructure for storing and transporting biological samples, so it is necessary to secure equipment for this purpose. Thus, the implementation of care pathways for people living with Chagas disease necessarily involves strengthening the LACENs in terms of infrastructure, supplies, and human resources.

Expanding Access to Electrocardiography Through Telemedicine Support. Once serological positivity is confirmed, the tested person must be incorporated into a well-defined care pathway. The first point of care is the same place where the testing was performed: the PHC unit. Currently, in Brazil, PHC is structured under the Family Health Strategy model, and care is provided within the context of Family and Community Medicine. Persons with positive serology for CD must initially be stratified according to the form of the chronic phase: indeterminate, cardiac, digestive, or mixed. The screening test used to characterize the cardiac form is the ECG. [59] This is a low-cost exam that can be performed in most municipalities, and access to it should be facilitated by PHC management. The ECG must be requested by the PHC professional as soon as persons are presented with the positive serology, in the context of counselling on CD and on the importance of the exam for the initial clinical classification. In chronic CD cardiomyopathy, the ECG often shows characteristic alterations that reflect myocardial fibrosis and conduction system damage. The most characteristic ECG finding in chronic Chagas cardiomyopathy is right bundle branch block, often combined with left anterior fascicular block; the coexistence of these two conduction abnormalities is considered highly

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suggestive of the disease. [59] Atrioventricular conduction disturbances are also frequent, ranging from first-degree AV block to advanced forms such as Mobitz type II and complete AV block. Ventricular arrhythmias represent another hallmark, with frequent and complex premature ventricular contractions, bigeminy, and episodes of non-sustained ventricular tachycardia, while atrial fibrillation or flutter may develop in more advanced stages. Repolarization abnormalities are common, typically with diffuse T-wave changes and electrocardiographic evidence of atrial or ventricular overload in dilated forms. Additional findings include sinus node dysfunction (such as sinus bradycardia or junctional rhythm) and, in some cases, low QRS voltage. Taken together, the combination of right bundle branch block, left anterior fascicular block, and complex ventricular arrhythmias constitutes the most distinctive ECG profile of chronic Chagas cardiomyopathy. [60] Given the complexity of arrhythmias associated with the cardiac form of chronic CD, a specialized ECG report issued by a cardiologist is essential. There is also the option of ECG reporting through telemedicine, a system already implemented in several Brazilian municipalities. [61] Once the ECG result is available, the Family Health Strategy physician will provide guidance to the patient: a normal ECG indicates the absence of chronic Chagas cardiomyopathy, whereas an abnormal ECG indicates the cardiac form of the disease and the need for referral to specialized outpatient care. In addition to supporting ECG analysis, telemedicine can be a useful tool in decision-making by professionals working at the PHC level, with guidance on the initiation of pharmacological interventions already indicated before the consultation with the specialist at the secondary care level, and for initial risk stratification.

Integrating Patients with cardiomyopathies from Other Causes. According to the I Brazilian Registry of Heart Failure, from 2011 to 2012, among 1,263 patients hospitalized with decompensated heart failure, the hypertensive, ischemic and CD etiologies prevailed affecting 30.1%, 20.3% and 11% of the patients, respectively. [62]. Globally, ischemic heart disease and hypertension are the most common causes of heart failure, and there are major discrepancies regarding access to combined guideline-directed medications with the lowest use in lower–middle-income and low-income countries. In addition, mortality rates are more than 2-fold higher in lower–middle-income and low-income countries. [63] Within developing countries there is also a great disparity in access to adequate treatment, so that, in Brazil, people living in poverty are highly vulnerable, depending entirely on the services offered by the SUS, as emphasized by non-governmental organizations. [64] Establishing a therapeutic pathway for people living with CD can be coupled with structuring support for patients who develop hypertensive, ischemic and other cardiomyopathies. These conditions are highly prevalent and, like CD, often require the establishment of care pathways that allow for transition between hierarchically organized care points (such as cardiology outpatient clinics) and depend on efficient referral and counter-referral systems.

Looking for symptoms of oesophageal and colonic involvement at primary health care. Digestive involvement in Chagas disease most frequently manifests as megaesophagus and megacolon, resulting from the destruction of the myenteric plexuses of Auerbach and Meissner. Within a CD care pathway, the search for signs of oesophageal or colonic involvement should begin at the PHC level. Patients with the indeterminate and cardiac form of Chagas disease should be routinely monitored for the onset of digestive symptoms. The initial symptoms are mild and may be nonspecific, often being attributed to other prevalent conditions such as gastroesophageal reflux disease and functional constipation. The presence of dysphagia, prolonged constipation, and dependence on laxatives should raise suspicion and prompt investigation of digestive involvement in CD. [65] Other symptoms may be present in patients with megaesophagus, including chest pain, regurgitation, and weight loss. These manifestations result from the incoordination between esophageal peristalsis and lower esophageal sphincter function, secondary to denervation of the myenteric plexus. [66,67] In advanced stages, malnutrition may develop due to the inability to swallow. Long-standing disease leads to

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oesophageal dilation, tortuosity, and stasis of undigested food, which increases the risk of oesophageal cancer compared with the general population.

Due to the indolent course of the disease, it is not uncommon for patients to develop adaptive behaviors over the years (chewing slowly, drinking fluids with meals, avoiding hard-consistency foods), which makes it more difficult for them to perceive dysphagia. A directed anamnesis aimed at identifying this symptom enables earlier diagnosis of megaesophagus. In suspected digestive involvement of Chagas disease, radiological contrast studies of the oesophagus and colon (barium enema) are recommended for diagnostic confirmation and disease staging. Findings may include delayed oesophageal emptying time, abnormal contractions, distal tapering of the oesophagus known as the typical “bird’s beak” appearance caused by lower oesophageal sphincter achalasia, and varying degrees of oesophageal dilation. Contrast esophagography can also be evaluated via telemedicine by specialists. In the colon, dilation predominantly affects the rectum and sigmoid, though it can extend throughout the colon. [68]

Treating Chagas disease with benznidazole. One of the main challenges in implementing a care pathway for people living with Chagas disease is the distribution of benznidazole, the only antiparasitic drug available in Brazil, produced by Lafepe (Laboratório Farmacêutico do Estado de Pernambuco) and distributed through the SUS. In acute CD, etiological treatment is indicated for all age groups and is lifesaving. In chronic disease, children and adolescents should always be treated; adults under 50 years with the indeterminate form are recommended for therapy, while those ≥50 years or with early cardiac involvement should be managed through shared decision-making. Benznidazole is weight-based (5 mg/kg/day for 60 days, maximum 300 mg), with treatment duration extended up to 80 days when dosing adjustments are required. [7] Patients require close monitoring for adverse events. The most frequent reactions are hypersensitivity-related skin rashes, usually mild and not requiring discontinuation, although 5% may develop moderate forms needing temporary interruption. Gastrointestinal symptoms occur in ~10% of patients and are usually manageable without dose adjustment. Peripheral polyneuropathy is a dose-dependent effect in adults, generally after the 5th week, requiring treatment suspension until symptoms improve. Less frequent effects include headache, fatigue, arthralgia, edema, and liver enzyme alterations. Rare but serious events, such as bone marrow hypoplasia or cytopenias, mandate immediate discontinuation. [69]

Eliminating Congenital Transmission of Chagas Disease. In Brazil, prenatal care under the SUS is delivered through PHC, ensuring universal access and high coverage. National guidelines recommend at least six visits, early initiation, routine laboratory tests, and vaccination. [70] Despite these advances, challenges remain: many women begin care late, follow-up is irregular among vulnerable groups. Structural gaps—such as limited diagnostic capacity and weak referral systems—still compromise equity and quality of prenatal care.[71-73] Pregnant women who have lived in areas with active vectorial transmission, in municipalities with an entomological history indicating household colonization by triatomines, with family members affected by CD, as well as in areas with oral transmission, or those who received a blood transfusion before 1992, should undergo serological testing for CD during prenatal care. It is therefore necessary to include CD serology in prenatal care protocols across vast areas of Brazil, including major urban centres to which these women may have migrated and where they are currently residing. The Ministry of Health establish the minimum serological tests to be performed during pregnancy in Brazil. These include screening for HIV, syphilis, hepatitis B, and toxoplasmosis, in addition to testing for rubella immunity and blood typing.[74] Although some regions already perform CD testing during prenatal care [75], there is still a great need to raise awareness among health teams to consolidate screening for pregnant women in Brazil. Testing must be performed in infants with suspected congenital transmission. Babies with positive parasitological tests (thick blood smears) and/or symptoms should be treated with benznidazole.

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Infants with negative parasitological tests can present positive serologic tests due to maternal antibodies, and if high antibody titres persist after 9 months of age (two positive reactions), this indicates congenital transmission. Even if testing is not performed at 9 months, children born to seropositive mothers can still be tested during the first years of life and start treatment with benznidazole, with an excellent likelihood of subsequent serological negativization.[76]

Engaging Communities in Day-to-Day Operations. Public participation in SUS management must be facilitated through the creation of Health Councils and Conferences, which aim to formulate strategies and monitor and evaluate the implementation of health policies. The implementation of a national policy for care for people living with Chagas disease would greatly benefit from the mobilization of people affected by the disease, catalysing their unity and organization, as is already a reality in several regions. Therefore, associations of people with Chagas disease should participate in health councils, raising demands and monitoring compliance.

Chagas Disease Care Pathways and the SUS Hierarchy of Care: Ensuring Comprehensiveness

Staging of Chagas disease cardiomyopathy. While PHC is decentralized and managed by municipalities, specialized outpatient clinics and polyclinics are often located in larger cities, requiring patients to travel. High-complexity hospital care is usually concentrated in state capitals. The implementation of a care pathway for people living with CD and other cardiomyopathies involves mapping the health care network, since specialized outpatient care will require cardiology clinics. As mentioned above, according to Saraiva et al. (2021) the cardiac form of CD is diagnosed when a person with a positive serological test presents typical ECG changes in the absence of other heart diseases that may cause these changes. [59] Once referred to the cardiology clinic, the cardiac form of CD and other cardiomyopathies will be clinically evaluated for symptoms of heart failure at its various stages. The CD cardiomyopathy classification currently used in Brazil is strongly supported by findings from two-dimensional Doppler echocardiography, an examination that must be available and easily accessible. [7] Stage A includes patients with abnormal electrocardiograms but no left ventricular wall motion abnormalities and no clinical signs of heart failure. Stage B1 refers to patients with abnormal electrocardiograms and echocardiographic evidence of left ventricular wall motion abnormalities, with preserved systolic function defined as a left ventricular ejection fraction (LVEF) ≥ 55%, and without symptoms of heart failure. Stage B2 includes patients with abnormal electrocardiograms and left ventricular wall motion abnormalities, with reduced systolic function (LVEF < 55%), but still without symptoms of heart failure. Stage C comprises patients with abnormal electrocardiograms and left ventricular wall motion abnormalities associated with compensated heart failure. Finally, Stage D refers to patients with abnormal electrocardiograms, left ventricular wall motion abnormalities, and refractory heart failure, despite optimized treatment. [7]

The staging of CD and other cardiomyopathies results in a risk stratification that is essential for decision-making within the care pathway. Patients in stage A, who present with ECG abnormalities but no echocardiographic alterations or symptoms of heart failure, may be counter-referred and included in a schedule of less frequent visits to the cardiology outpatient clinic. This approach, however, does not apply to patients in more advanced stages, who require closer follow-up and specialized care.

In patients with CD cardiomyopathy, pharmacological management largely follows the general principles of treating heart failure and arrhythmias, with some considerations due to the unique pathophysiology of the disease. [7] For heart failure with ventricular dysfunction, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, beta-blockers such as carvedilol,

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bisoprolol, or metoprolol succinate, and mineralocorticoid receptor antagonists are commonly prescribed, while diuretics are used for symptomatic relief of congestion. Arrhythmias are frequent, and amiodarone remains the antiarrhythmic agent most widely employed, particularly for ventricular tachyarrhythmias, while conduction system disease often requires pacemaker implantation. In selected high-risk patients, implantable cardioverter-defibrillators may also be indicated to prevent sudden cardiac death. Anticoagulation is reserved for those with intracardiac thrombi, atrial fibrillation, or a history of embolic events, given the high risk of thromboembolic complications. [7]

Ensuring High-complexity Hospital Procedures. People living with CD and other cardiomyopathies may eventually require high-complexity hospital procedures. These include the implantation of permanent pacemakers, implantable cardioverter-defibrillators, and cardiac resynchronization therapy, as well as catheter ablation for ventricular or supraventricular arrhythmias that are recurrent, symptomatic, or refractory to pharmacological treatment.[77-79] In more advanced cases, surgical interventions such as repair of apical aneurysms or removal of intracardiac thrombi, in addition to heart transplantation, may be necessary.[80] Furthermore, intensive care unit admissions may be required for the management of severe decompensations.

In chronic CD, pacemaker implantation is indicated primarily for advanced atrioventricular block, including second-degree Mobitz II and third-degree (complete) AV block, even in the absence of symptoms due to the risk of sudden death. It is also indicated for symptomatic bradyarrhythmias, such as bradycardia causing syncope, dizziness, or severe fatigue, as well as for sinoatrial node dysfunction with prolonged pauses. [7] Additionally, conduction disturbances associated with syncope or presyncope, such as bundle branch blocks combined with fascicular blocks, may warrant pacemaker implantation. In advanced CD, isquemic and hypertensive cardiomyopathy, heart transplantation is indicated primarily for patients with refractory heart failure who remain symptomatic despite optimized medical therapy. It is also considered for patients with severe ventricular arrhythmias, such as recurrent sustained ventricular tachycardia or ventricular fibrillation not controlled by antiarrhythmic drugs or an implantable cardioverter–defibrillator. [7] Severe left ventricular dysfunction, with an ejection fraction below 20–25% and persistent symptoms, constitutes another indication. Additionally, transplantation may be required in cases of cardiogenic shock or hemodynamic instability that is unresponsive to conventional therapy, often necessitating mechanical circulatory support as a bridge to transplant. This continuum of care, which will be required for some patients, illustrates the need for mapping and consolidating a network with points of care of ascending complexity and efficient referral and counter-referral flows, integrated within a regulatory system.

Addressing the digestive form at secondary and tertiary levels of health care in the SUS. Upper gastrointestinal endoscopy and oesophageal manometry may be indicated in the follow-up of patients with the digestive form of Chagas disease (the latter particularly in suspected cases with normal contrast studies and endoscopy). [81] Once the diagnosis is confirmed, conservative treatment may be instituted in mild or oligosymptomatic cases, including dietary and behavioral measures and, in some cases, pharmacological therapy with calcium channel blockers or nitrates, which act on the lower esophageal sphincter muscle and can provide symptomatic relief of dysphagia in some patients. [82] These drugs, however, are sometimes poorly tolerated due to side effects such as headache and dizziness. Osmotic laxatives may be useful in the management of megacolon. More symptomatic or advanced cases should be referred for specialized evaluation by a gastroenterologist. As part of the care of patients with CD ensuring access to specialized services is of paramount importance for those with digestive manifestations. This access is particularly relevant for patients requiring endoscopic treatment

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(such as pneumatic balloon dilation or peroral endoscopic myotomy) or surgical treatment of megaesophagus and megacolon.

Particularities of the Amazon Region. In the Amazon region, the distances between primary, secondary, and tertiary care facilities within the hierarchical structure of the SUS are exceptionally vast, often requiring river travel lasting more than 24 hours and covering several hundred kilometers. Consequently, certain interventions must be implemented at the local level, which underscores the need to strengthen telemedicine and ensure the availability of high-cost medications for treatment of heart failure through primary health care units. This distribution flow entails complex logistics, yet it must be undertaken by municipal SUS managers at the local level, with support from state authorities**.**

Robust policies addressing the hygiene of foods obtained through extractive practices are essential, given the high incidence of food-borne cases, together with the implementation of permanent education programs for healthcare professionals and the community. This will require investments and strong coordination among municipal, state, and federal SUS managers.

Chagas disease and HIV/AIDS

Reactivation of CD in people living with HIV is a severe and often life-threatening condition, particularly when CD4 counts fall below 200 cells/mm³, resulting in increased parasitemia due reactivation of dormant *T. cruzi* amastigotes. Clinical manifestations frequently include meningoencephalitis, cerebral space-occupying lesions, and acute myocarditis, conditions associated with high mortality if diagnosis and treatment are delayed. Prompt recognition of reactivation and initiation of benznidazole therapy, combined with optimization of antiretroviral therapy, are critical to improving outcomes. For this reason, integration of Chagas disease screening and monitoring into HIV/AIDS programs in endemic areas is strongly recommended. (83)

The Amazon region deserves particular attention in this syndemic scenario. While historically less affected by domiciliary vector transmission, the Amazon currently accounts for most new incident cases of CD in Brazil, mainly due to transmission through oral exposure and sylvatic cycles, as mentioned above. At the same time, the incidence of AIDS in the Amazon is higher than the national average, amplifying the overlap of both infections. This convergence creates a unique epidemiological challenge, where fragile health systems, geographic barriers, and social vulnerability hinder access to timely diagnosis, parasitological treatment, and highly active antiretroviral therapy. Strengthening integrated care pathways that address both HIV and Chagas disease, with an emphasis on early detection and prevention of reactivation, is therefore an urgent public health priority.

Concluding Remarks

The SUS is organized under strict principles, and a care pathway for CD must acknowledge this structure. All SUS principles should permeate any policy that seeks to include CD in public health priority programs and in the construction of a national strategy for health care. In this context, *Universality* means free access, and for Chagas disease it implies, among other aspects, the inclusion of immigrants from other Latin American countries who have settled in Brazil. *Equity* requires investing more where needs are greater, identifying regional priorities through the mapping of highly vulnerable, remote, and poor areas with a high prevalence and burden of morbidity. *Comprehensiveness* refers to care provided at all levels of complexity, encompassing health promotion, prevention, treatment, and rehabilitation of the severe cardiac and digestive forms of the disease. *Decentralization* entails municipal autonomy and management at the PHC level, with adaptation of strategies to local realities. *Hierarchization* requires the establishment

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of a patient care pathway governed by efficient referral systems and the mapping of care points across ascending levels of complexity. Finally, *Popular Participation* means engagement, organization of associations of people living with Chagas disease, and their participation in municipal health councils, with the aim of demanding and monitoring actions. [84] Ensuring that these principles are upheld for people living with CD and other cardiac conditions, including cardiomyopathies, is essential so that they may not only survive, but live with dignity, resilience, and a renewed sense of hope.

Conflict of interests

The authors declare no conflicts of interest.

Authors' contributions

FAC-C organized the manuscript and developed issues related to the organization of the Unified Health System (SUS). DSMS and JMBF addressed cardiology-related care issues, while LDDF organized the section on digestive involvement. JAOG and PAV contributed to structuring care pathways with a regional focus, and ACVJ supervised the work, developed issues related to the Amazon, and revised the manuscript.

Data availability statement

The concepts and ideas developed and/or analyzed in the present study are available from the corresponding author on reasonable request.

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