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EMERGING VECTOR BORNE DISEASES IN THE U.S. (JK PETERSON, SECTION EDITOR)

Our Current Understanding of Chagas Disease and *Trypanosoma cruzi* Infection in the State of Florida — an Update on Research in this Region of the USA

Norman L. Beatty[1,2] · Colin J. Forsyth[3] · Nathan Burkett-Cadena[4] · Samantha M. Wisely[2,5]

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Abstract

Purpose of Review Chagas disease (CD) is a neglected tropical disease caused by the protozoan parasite, *Trypanosoma cruzi*. Parasite transmission primarily occurs through direct interaction with an infected triatomine insect vector (kissing bug), but other routes are known. We aim to review the literature and discuss the unique circumstances of CD in the US state of Florida.

Recent Findings Florida is home to naturally occurring kissing bugs that are invading homes and harbor *T. cruzi*. The state is also home to a diverse population of immigrants from Chagas-endemic regions in Latin America. In the USA, Florida is the state with the third highest estimated burden of CD, although the true prevalence is unknown.

Summary Chagas disease is a chronic infection that often remains silent for decades. Those who manifest chronic disease may eventually die from debilitating cardiac and/or gastrointestinal manifestations. Florida is an opportune region of the USA for the study of CD, due to the existence of endemic transmission cycles in addition to the burden among people born in Chagas-endemic regions.

Keywords Chagas disease · *Trypanosoma cruzi* · Florida · Neglected tropical disease · Kissing bug · Triatomine

Introduction

Chagas disease (CD) is a neglected tropical disease endemic to at least 21 Latin American countries. Approximately 75 million people are at-risk, and six to seven million people worldwide are estimated to be infected [1–3]. The etiological agent of Chagas disease is the protozoan *Trypanosoma cruzi.* Parasite transmission occurs via direct interaction with an infected triatomine bug vector known as the "kissing bug" [4•]. Other known routes of transmission include oral ingestion of *T. cruzi*–contaminated food products and beverages, transplacental infection (infected mother to fetus in utero), and blood transfusion or organ transplantation from *a T. cruzi*–infected donor [2, 3, 4•]. Some experts have proposed other potential routes, including infection from contact with mammalian host(s) infected with *T. cruzi*, such as contamination of the environment with opossum anal gland secretions or eating under undercooked wildlife meat infected with *T. cruzi* [5, 6]. Such contact may contribute to further infection among other mammals and possibly even human beings [7]. Diverse mammal species, including humans, serve or can serve as *T. cruzi* reservoir hosts that allow the

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✉ Norman L. Beatty
norman.beatty@medicine.ufl.edu

1 Department of Medicine, Division of Infectious Diseases and Global Medicine, University of Florida College of Medicine, 1600 SW Archer Rd, Gainesville, FL 32610, USA

2 Emerging Pathogens Institute, University of Florida, Gainesville, FL, USA

3 Drugs for Neglected Diseases Initiative-North America, New York City, NY, USA

4 Entomology and Nematology Department, Florida Medical Entomology Laboratory, University of Florida, Vero Beach, FL, USA

5 Department of Wildlife Ecology and Conservation, University of Florida Institute of Food and Agricultural Sciences, Gainesville, FL, USA

parasite to complete its life cycle as an obligate intracellular parasite [4• , 7].

In the USA, more than 300,000 people are estimated to be living with CD among those who have emigrated from endemic regions [8, 9•]. Unfortunately, less than 1% of infected persons have been diagnosed, and Florida is thought to carry the third highest *T. cruzi* infection burden among US states, with an estimated 18,000 people infected [9•]. Epidemiological studies have shown that approximately 30% of those with serological evidence of infection will develop a potentially fatal chronic illness. Clinical manifestations include dilated cardiomyopathy and progressive heart failure, cardiac arrhythmias that can advance to cardiac arrest, gastrointestinal and neurological diseases, as well as thrombotic events, such as stroke and pulmonary embolism [1–3, 10–13].

Triatomine bugs (Hemiptera: Reduviidae: Triatominae), the only known vectors of *T. cruzi*, occur in Florida, and have been shown to harbor the parasite [14]. Two species of *Triatoma* are considered native to Florida (*Triatoma sanguisuga* and *Triatoma lecticularia*), and another potentially invasive species (*Triatoma rubrofasciata*) has been recorded at a seaport in Florida [4•]. Some studies have investigated sylvatic reservoirs and identified infected wildlife in Florida [4•], but data are limited and the extent of *T. cruzi* transmission in the state is largely unknown. Our objective is to review the existing literature and address current research being done to help understand the scope of CD in Florida, both among immigrant populations and autochthonous transmission among susceptible mammalian hosts.

Chagas Disease in the USA

The extent of CD in the USA is unknown and the only national prevalence estimates come from blood bank data collected by the American Academy of Blood Banks Chagas Biovigilance Network between 2007 and 2019. A total of 2462 confirmed cases of CD are reported over this 13-year period among blood donors nationally [15]. Regional studies among at-risk Latin American populations have found individuals with CD in several US communities. A landmark study conducted in Los Angeles County revealed a prevalence of 1.24% in a cohort of 4755. The authors estimate that 30,000 or more individuals in the greater Los Angeles area may be living with CD [16•]. Furthermore, among this same population, 189 family members of 86 CD patients were tested and 7.4% (N = 14/189) also had CD [17]. A similar study in the Washington D.C. metropolitan region revealed an overall prevalence of 3.8% in a convenience sample of 1514. The majority of those with serological evidence of infection in this study was born in Bolivia or El Salvador [18]. Finally, the largest known assessment to date has been conducted in east Boston (well outside the known range of any CD vector species), revealing a seroprevalence of 0.9% among N = 8142 Latin Americans who have been screened [19]. In the USA, few large-scale studies have assessed transplacental infection among at-risk mothers who have immigrated from endemic regions. This is another area that needs attention in the USA. A review of the literature conducted by Edwards and Montgomery [19] highlights the importance of pregnancy-based screening, which has been shown to be cost-effective and efficacious in identifying new cases in mothers and infants [20]. In Texas, one study revealed a prevalence of 0.25% among N = 3376 Latin American pregnant women who were mainly of Mexican descent [21]. More research is needed to better understand the dynamics of CD among our diverse population of Latin Americans living in the USA.

Chagas Disease in Florida

Overview

Chagas disease in Florida, as elsewhere in the USA, is highly neglected by the health care system. Very little is known on the actual prevalence of CD in the state, and a statewide assessment among at-risk Latin American populations is needed. This would include screening those who were born in or who have lived in endemic countries for more than 6 months, those exposed to the vector in endemic countries and here in the USA (including Florida), and those with known family members with CD [22••]. Furthermore, CD is not a reportable disease to the Florida Department of Health, which severely limits the ability to track any cases that are found from routine blood and organ donor screening or other clinical concerns for the disease.

Chagas disease neglect is especially concerning in Florida, due to the high numbers of residents born in Chagas-endemic regions of Latin America. According to the most recent U.S. Census data, approximately 5.6 million people in Florida identify as Hispanic or Latino (26.5% of the total population of Florida; [23]), but the true number of people who emigrated from Chagas-endemic regions is difficult to estimate due to the ebb and flow of undocumented migration. The Migration Policy Institute estimates that at least 666,000 Central Americans (including Mexico) and 916,000 South Americans are living in Florida. Our calculations based on census data suggest the number to be somewhere around 2.8 million [23]. Additionally, Florida is a major US destination for Venezuelan immigrants seeking temporary protective status or asylum. Migration from Venezuela alone was projected to rise to 7 million in 2021 [24]. Data from U.S. Census Bureau 2018 ACS reveal that more than half of Venezuelan immigrants to the USA reside in Florida [25].

The reported prevalence of CD in Venezuela has changed over time but estimates suggest that certain regions have as high as 11.7% and 12.5% seroprevalence, including a recent report indicating 15.7% national seroprevalence among certain regions in the country [26, 27]. Migration of individuals from Latin America due to humanitarian crises likely impact states like Florida due to these fluctuating movements of people at-risk for the disease prior to immigration.

We know that CD exists among at-risk populations in the state, based on blood bank data and a single case study. Since 2007, the American Academy of Blood Banks initiated guidelines on screening blood donors for CD among Latin American populations after blood-product related *T. cruzi* infection was found among recipients of these products from infected donors [4•]. From 2007 to 2019, Florida had the second highest number of blood donors in the USA, with 325 confirmed cases of CD, second only to California (n = 890; [15]). However, these cases represent just 1.8% of the estimated 18,000 people living with *T. cruzi* infection in Florida [7]. Several other studies have shown increased *T. cruzi* prevalence among Florida blood donors with serological evidence of CD [25, 29, 30]. One such study found that, in 2008, 1:3800 blood donations were positive for CD screening assays among 14 million donations studied. This finding was the highest *T. cruzi* seropositivity rate found in the USA at the time [30].

Transplacental *T. cruzi* transmission has also been documented in Florida. Two adult males born in the USA to a mother from Bolivia had confirmed CD. Neither son had vector exposure, so the case was considered to be probable congenital transmission. One of the sons had evidence of chronic CD and likely cardiac involvement while the other did not have clinical evidence of disease at the time of publication [31]. The true extent of transplacental *T. cruzi* transmission in Florida is unknown, and efforts are needed to implement screening among at-risk women seeking prenatal care.

Current Research

Presently, our team at the University of Florida with support in part from Mundo Sano Foundation and Drugs for Neglected Diseases Initiative are conducting a statewide prevalence study to assess CD among at-risk Latin Americans, following new guidelines for screening and diagnosing CD in the USA [22••]. Using rapid lateral flow diagnostic tests (Chagas Detect™ Plus; InBios International, Inc.; DPP® Chagas System; Chembio Diagnostic Systems, Inc.) in primary care and mobile clinic settings (Fig. 1), we have unearthed new cases of CD, but our work is ongoing at the time of this submission. We aim to collect enough data to generate the first state-wide Chagas disease prevalence assessment in Florida over a 3-year investigation.

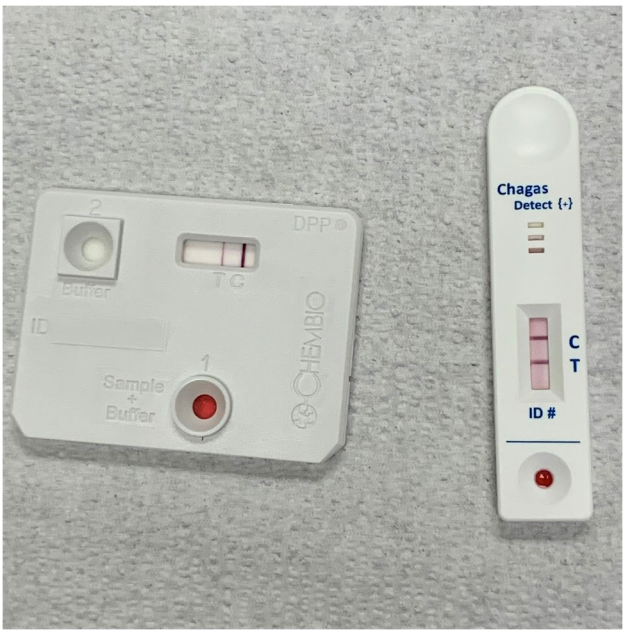

Fig. 1 Rapid diagnostic Chagas disease testing (Left — DPP® Chagas system, Chembio Diagnostic Systems, Inc., Hauppauge, NY, USA; Right — Chagas Detect ™, InBios International, Inc., Seattle, WA, USA) of a patient from El Salvador who tested positive in the clinic and later confirmed to have Chagas disease

Triatomine Bugs in Florida

Overview

Triatomine research in Florida has received little attention compared to other vector groups, particularly mosquitoes (Diptera: Culicidae) and no-see-ums (Diptera: Ceratopogonidae: *Culicoides*). Current and past research indicates that triatomine bugs in the state are widespread, are *T. cruzi* competent, and that some populations do live in close proximity to humans and their animals. Modern molecular techniques can be applied to triatomine research to better understand their importance in *T. cruzi* transmission risk in Florida.

Triatomine Species

Two species of triatomine bugs are endemic to the state of Florida (Fig. 2), *Triatoma sanguisuga* (LeConte) and *Triatoma lecticularia* (Stal). The two species are easily differentiated by presence (*T. lecticularia)* or absence (*T. sanguisuga*) of dark "hairs" covering the body (pubescence; [32]). Both species were formerly designated subspecies which were determined based upon the size of the adult

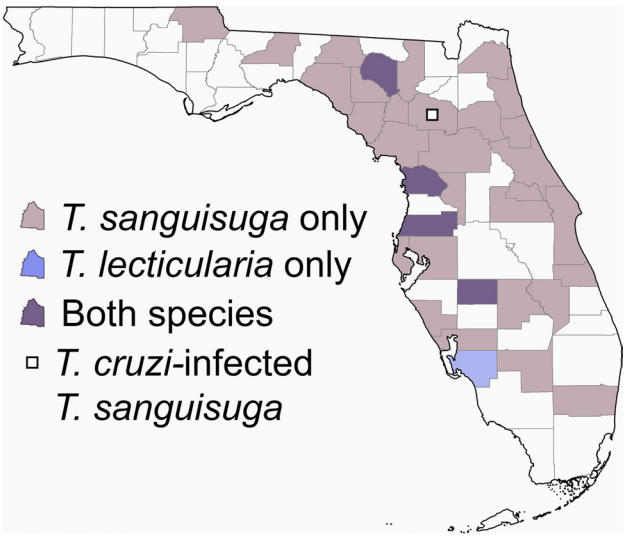

Fig. 2 Map of triatomine distribution in Florida. Distribution records are compiled from published sources [12, 25, 26]

and minor differences in geographical distribution. Validity for the subspecies designations was not supported by a thorough taxonomic revision [33], although the topic has not been revisited with molecular techniques. Relatively little research has been published on Florida triatomines, compared with states in the southwestern USA, such as Texas or Arizona. The most thorough studies were conducted over 50 years ago, beginning with work by Thurman et al. [31], who provided a useful key to Florida *Triatoma* with valuable distribution records revealing our first statewide record. Thurman's robust entomological survey was conducted over 4 years and yielded *Triatoma* spp. collected from a total of 32 counties [32]. This assessment included previous field work conducted by Usinger's original work on *Triatominae* [34]. A further detailed collection conducted by Irons Jr. and Butler investigated 15 sites among five counties (Alachua, Hardee, Leon, Levy, Orange) over a 2-year period from 1969 until 1971. They describe immature nymphs and adults being found year-round and associated with certain sylvatic habitats. This includes fallen trees and stumps, and loose bark of rotting logs primarily located near animal runs [35]. Interestingly, nymphs were frequently found in the presence of the Florida wood-roach (*Eurycotis floridana*), which may have been acting as a food source in times of starvation [36]. Over the last four to five decades since the majority of triatomine research was conducted in Florida, our state has changed drastically with respect to overall population growth and environmental changes such as human development of natural spaces. These changes have increased human exposure to sylvatic and peridomestic vectors such as ticks [37, 38], mosquitoes [39, 40], and even triatomines [41, 42] throughout the globe, supporting the need for ongoing research of this vector here in Florida.

Triatoma sanguisuga (s.l.) is considered to be the most widespread and common triatomine species in Florida, and has been recorded virtually statewide, including in the panhandle and the north, central, and southern regions of the state [32]. *Triatoma sanguisuga* (recorded as now-defunct subspecies *Triatoma sanguisuga ambigua* (Neiva), and *Triatoma sanguisuga sanguisuga* (LeConte), has been found in 31 of 32 Florida counties sampled in this survey among a total of 67 counties in the state [32]. *T. sanguisuga* was found from Jackson County in northern Florida to Broward County in southern Florida.

Triatoma lecticularia (Stal) is not considered to be common in Florida and is infrequently reported in published entomological surveys [32–34]. The recorded distribution of this species in Florida is restricted to the Gulf Coast Counties (Citrus, Pasco, and Lee Counties) and two inland counties (Suwanee and Hardee [32, 33]). Very little is known about the biology of *T. lecticularia,* including its potential for transmitting *T. cruzi*. The species is distributed widely throughout the southern USA and the border state of Nuevo Leon in northern Mexico [33]. The species has been found naturally infected with *T. cruzi* in Texas [4•], so it could theoretically play a role in *T. cruzi* transmission to humans in Florida. *T. lecticularia* is considered a sylvatic species that is typically associated with rodent nests. We have not found *T. lecticularia* in our sylvatic or peridomestic field work in Florida, and we suspect that it is an elusive triatomine species that poses a low epidemiological risk to human beings.

Triatoma rubrofasciata (De Geer) is an invasive species that has been recorded from historical collections in Jacksonville, Florida [4•]. However, it is unclear if the species is still present in Florida, as it has not been reported in > 50 years, nor collected in our current entomological survey work.

T. cruzi infection in field-collected triatomines

The first detection of *T. cruzi* from a field-collected Florida triatomine was described by Beard et al. in 1988 [14]. *Trypanosoma cruzi* was successfully cultured from an adult female *T. sanguisuga* individual that was found at night on a screened door of a lit porch in Gainesville, Florida. Previous attempts to detect *T. cruzi* in triatomines from Florida until this point had yet to find *T. cruzi* infection, including a survey of 99 triatomines collected in north Florida [28]. Since detection of this naturally infected Florida triatomine in 1988, not much was done by local researchers to further investigate *T. cruzi* among Florida triatomines. However, findings from a national citizen science program conducted at Texas A&M (TAMU) have recently revealed human interaction with triatomines in Florida [43]. The research demonstrated that in Florida, *T. sanguisuga* that invaded homes,

was found commonly in the peridomestic environment and was infected with two distinct *T. cruzi* DTU's (DTU tcIV and DTU TcI) [44, 45].

Current Research

Our team at the University of Florida is conducting research into the ecological and environmental associations with triatomine bug presence in and around human homes in Florida. So far, we have collected over 300 *T. sanguisuga* specimens throughout the panhandle, northern, and central Florida regions. We have yet to isolate the species in southern regions, likely due to sampling bias. Our preliminary analysis reveals that the majority of triatomines collected were in the adult stage (Fig. 3) and were found inside or around human dwellings. The homes were typically located in rural settings or in suburban landscapes located close to the interface with wild spaces. Several homes with triatomines have been identified due to residents being bitten by the insect. Nymphal triatomine stages (Fig. 4) have also been found nearby or inside human dwellings, and we are investigating the possibility of domiciliation, but this is unclear at this time.

Trypanosoma cruzi Infection in Wildlife and Companion Animals

A wide range of mammal species in the USA have been shown to be infected with *T. cruzi*, including the North American raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), gray fox (*Urocyon cinereoargenteus*), armadillo (*Dasypus novemcinctus*), and multiple species of woodrat (*Neotoma* spp.) and other rodents [4•, 46•]. Other species have been documented to produce antibodies to *T. cruzi*, and are considered potential reservoirs including bobcat (*Felis rufus*), and coyote (*Canis latrans*; [47]).

Fig. 3 Adult female *Triatoma sanguisuga* found in the bed of a homeowner located in Osceola County, Florida, who had been bitten

Fig. 4 (Top) University of Florida graduate students, Chanakya Bhosale (left) and Carson Torhorst (right) investigating lumber pile near a resident's home who had been bitten by a triatomine. (Bottom) Collection revealed dozens of *Triatoma* spp. nymphs from 1st to 5th instar

In Florida, sylvatic *T. cruzi* transmission among wildlife reservoirs has been found, but data are sparse. Brown et al. [46•] sampled racoons and opossums from three Florida counties (Leon, Wakulla, Hendry), and found that 54% of racoons (n = 38/70) and 52% of opossums (n = 14/27) were seropositive via indirect immunofluorescent anti-*T. cruzi* antibody testing [47]. In mammals collected from Georgia and Florida, the authors found that 30% (50/168) of raccoons and 13% (11/83) of opossums were *T. cruzi* culture positive. Finally, an earlier investigation of *T. cruzi* genotypes from 107 isolates from wild mammals in the USA found that DTU 1 was the predominant *T. cruzi* genotype in Florida racoons and opossums [48].

Perhaps also meriting attention are non-human primates (NHP) in Florida. A 2018 study of 980 captive NHP (rhesus macaques) in Texas found that 4% of the macaques sampled (41/980) were seropositive for *T. cruzi,* of which 33 (80%) were also PCR positive for the parasite [49]. In the 1930s, rhesus macaques were introduced into Silver Spring State Park in central Florida in an effort to bolster tourism to the

area [50]. A troop of approximately 12 macaques were intentionally released during that time, and the population grew to an estimated 400 or more animals in the 1980s, and spread to an adjacent forest in a region along the Ocklawaha River [50, 51]. In 2015 and 2016, Wisely et al., working with local wildlife trappers, collected venous blood from 317 macaques in order to test them for macacine herpesvirus-1. The assessment revealed that rhesus macaques still thrive in the Silver Spring State Park (5000 total acres), which is adjacent to the Ocala National Forest (387,000 total acres) in north central Florida [52]. Currently, there are three species of non-native NHP populations in Florida, including *Saimiri* spp. (squirrel monkey), *Chlorocebus pygerythrus* (vervet monkey) and as discussed, the *Macaca mulatta* (rhesus macaque; [50]). Squirrel monkeys, which are found naturally in endemic regions of Chagas disease, can be naturally infected with *T. cruzi*, as well as *Macaca* spp. in non-endemic regions, including the USA [49, 53, 54]. Captive or invasive NHPs living in Florida have yet to be investigated for *T. cruzi* infection but given reports of known populations into the hundreds (exact number unknown) of free-ranging invasive NHP in the north central and possibly other regions of south Florida [50, 52], these populations could play a role in the maintenance of sylvatic *T. cruzi* transmission in the state.

Finally, companion animals can be infected with *T. cruzi*, and awareness is increasing in the USA that both domestic canines and felines are at risk [46•]. Several studies have found *T. cruzi* infection among domestic mammals and zoo-raised exotic mammals [46•], but there is no research on the subject in Florida. Researchers in Texas have found widespread *T. cruzi* infection among canines, including working government and military dogs [55]**.** *T. cruzi* infection among mammalian pets such as cats and dogs may serve as a source for ongoing peridomestic and/or domestic infection cycles near human dwellings. The increase of small ruminant livestock and chicken flocks in urban and periurban US households [56] may also serve as a source for increasing triatomine exposure near the human dwelling. Birds are not competent *T. cruzi* hosts, but they do serve as a food source for the vectors. Further research is needed in Florida to assess the role of synanthropic animals in *T. cruzi* transmission cycles.

Current Research

Our team at the University of Florida is investigating raccoons and opossums in Florida to assess their role in peridomestic or even domestic transmission cycles. Preliminary findings have detected *T. cruzi* in both rural and urban racoons and opossums in north Florida [57]. *T. cruzi* DNA was detected in 26% (18/69) of opossums and 5% (3/55) of raccoons sampled. Our work is ongoing, and more research is needed to better understand the community of mammalian reservoirs and the prevalence of *T. cruzi* infection in Florida animals.

Risk for Human Autochthonous Transmission in Florida

Autochthonous transmission of CD in the USA has been suspected or confirmed in Texas, California, Arizona, Tennessee, Louisiana, Missouri, Arkansas, and Mississippi [4•]. *T. cruzi* transmission to humans through exposure to *T. sanguisuga* vector-borne exposure has been found in southeastern portions of the USA, including an infestation documented in rural New Orleans, Louisiana [58]. In Florida, *T. cruzi* has been found to infect triatomine bugs, wildlife, and companion animals such as domestic canines [14, 46•, 47, 48, 55, 57]. At this time, a human case has not been described. Nonetheless, Florida does have all the necessary elements to permit *T. cruzi* transmission to humans, including *T. cruzi*-infected triatomines invading human dwellings [44, 45, Beatty pers. comm.] and a changing landscape, which may facilitate further triatomine invasion or establishment in peridomestic or domestic areas.

Triatomine invasion into human dwellings was first documented during our field investigations in Florida in 2019 (Fig. 4), and interestingly the first known *T. cruzi* infected triatomine was found on someone's porch in Alachua County in 1986 [14]. In fact, the earliest historical entomological surveys conducted by Usinger et al. and Thurman et al. in 1944 and 1947 document triatomines collected at human dwellings and other domestic animal structures, like chicken coops [32, 34]. Triatomines near human homes have been described in other regions of North America [4•, 5] and well documented in Texas, where multiple autochthonous human Chagas disease cases have been described [59]. This includes a recent case of acute Chagas in a rancher from central Texas who presented with classic features of Romaña's sign and *T. cruzi* DNA isolated from the blood [60•]. Canine Chagas disease appears to be common in Texas in certain regions, and may act as a sentinel for peridomestic and domestic transmission in and around human inhabitants, thus emphasizing the need for more research on the subject in Florida.

Anthropogenic landscape changes of wild spaces may also impact triatomine biology and likely *T. cruzi* sylvatic cycles in endemic regions of Chagas disease. One such study looking at deforestation in eastern Amazonia has shown that manipulating the natural landscape can increase vector-population densities in this region [61]. Florida, like many regions of the USA where triatomines inhabit the landscape, may be at risk for increasing exposure to the vector due to deforestation and resulting changes to vector ecology, which may facilitate peridomestic invasion into the human

habitation (Fig. 5). More research is needed to better understand how anthropogenic landscape changes can impact the risk that Florida's residents and its millions of annual visitors face for vector-borne diseases like Chagas.

Improving Knowledge, Awareness, and Linkage to Care for those with Chagas Disease

Within the USA and including Florida, few people get tested for CD outside of routine screening among blood and organ donations. Moreover, it is likely that few of the individuals with confirmed positive results have received treatment and management. According to the Centers for Disease Control and Prevention only 15 of the 365 people who received benznidazole under Investigational New Drug Protocols from 2011 to 2018 were treated by physicians in Florida, or about 2 people per year [62]. While both benznidazole (2017) and nifurtimox (2020) are now FDA-approved, most people with Chagas disease remain without access to testing and treatment.

Several interrelated barriers perpetuate the neglect of CD in the USA [8, 63]. One of the biggest barriers is low awareness, both among healthcare personnel and people at risk. Because of the disease's long asymptomatic phase, most people are unaware they have the infection, so provider-initiated screening is critical for identifying patients. Several studies have documented low awareness of CD among healthcare providers in the USA [20, 64–66], and patients with CD have indicated this lack of awareness as a major impediment to accessing testing [67•]. Considering that up to 86% of people at risk may have never heard of Chagas disease [68], there is also an absence of information, education and communication activities directed toward the disease, which is a critical public health gap.

Fig. 5 Parcel of north Florida deforestation in Alachua County, Florida, close to a home with *Triatoma sanguisuga* peridomestic invasion

Nonetheless, even if healthcare providers recognize the importance of CD, simply testing patients and navigating them to care can pose major challenges. In a recent survey of obstetricians-gynecologists and Family Medicine practitioners (N = 178), most considered CD to be an important public health concern. However, 2/3 were unsure of how to order a test, and fewer still were certain what to do with a positive test result [69]. Of the four assays with FDA clearance for clinical use, only one is a point-of-care test [22••] which may limit the ability to screen the most vulnerable and underserved populations such as farmworkers and other seasonal or temporary workers with limited resources. Moreover, CD testing may not be accounted for in medical information systems, and providers may not be aware of criteria for diagnosis or in which cases antiparasitic treatment should be initiated.

On the other hand, new guidelines are available in the USA to help clinicians understand what populations should be screened and how to navigate a diagnosis of CD in the USA [22••]. For example, people who were born in or with significant travel to a CD endemic region (21 countries in total) located in Mexico, Central or South America should receive CD testing at least once [22••]. In Florida, this guideline will ideally lead to increased awareness and clear standards linking at-risk populations to necessary testing. Given that the at-risk population is heterogeneous, ranging from business owners and service workers in major urban centers to seasonal workers in agricultural areas throughout the state, attention will be needed to reach this diverse community and the clinical providers who care for them. One strategy being undertaken is the use of rapid, point-of-care CD testing that can provide screening in the outpatient clinic and other mobile health care venues like health fairs. Results are generally ready within 15–20 min, easy to administer with a single drop of blood, and provide sensitivity reported between 93.6 and 97.5% among US-based populations [18, 70], thus allowing for ideal screening opportunities.

Comprehensive training of the healthcare workforce in identification of CD risk factors and processes for diagnosis and treatment is needed in the state of Florida. A state task force dedicated to CD linked with a network of providers in key locations throughout the state could also help ramp up testing and treatment. An awareness campaign targeted to people at risk, based on linguistically and culturally appropriate messages, should accompany these efforts to encourage demand for testing [100].

Conclusions

CD is one of the most hidden, neglected diseases in the USA, and poses a public health challenge demanding urgent attention. There are significant gaps in epidemiological

knowledge of the incidence, prevalence, and transmission; evidence provided by ongoing and future research in Florida will provide key pieces of the puzzle. Florida is a state with both naturally infected vectors and mammalian hosts of *T. cruzi*, which drives concern for the potential of autochthonous transmission to our mammalian companion animals and ourselves. Furthermore, this region of North America is home to a diverse population of Latin Americans who have emigrated from endemic regions where *T. cruzi* DTU strains are different and serological testing can be discordant. Guidelines are now available for health care providers who are practicing in the USA which will hopefully bring awareness and further aid in screening and diagnosing at-risk populations with CD. Creating comprehensive public health responses in Florida and other high-burden states that focus on raising awareness, building capacity among healthcare providers to address CD, including adequate diagnosis and timely antiparasitic treatment, and strengthening research to better understand the epidemiology of the disease, including the local risk of vector transmission, will be key to addressing this hidden public health challenge.

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Declarations

Conflict of Interest Dr. Beatty reports funding to conduct Chagas disease research from Mundo Sano Foundation (AWD08818). All other authors declare that they have no conflict of interests.

Disclaimer All the figures are original and have not been published previously. The Florida triatomine distribution map (Fig. 2) is an original creation by Dr. Burkett-Cadena, produced by compiling data from older publications. It is not an adaptation of a previous work.

Human and Animal Rights and Informed Consent All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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•• Of major importance

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