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Chagas Disease Infection Prevalence and Vector Exposure in a High-Risk Population of Texas Hunters

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Abstract. Chagas disease, caused by the vector-borne parasite *Trypanosoma cruzi*, remains one of the most significant neglected tropical diseases affecting the Americas. Identifying high-risk populations is important for understanding Chagas disease transmission and directing public health resources. We recently hypothesized that Texas hunters may be at an elevated risk for contracting Chagas disease because of opportunities for vector exposure and contact with blood of infected reservoirs. To assess their unique exposure risks, we conducted a statewide screening program of Texas hunters. A total of 885 study participants were interviewed and tested for *T. cruzi* infection; 18 screened positive on a rapid, point-of-care test; however, none were found positive through confirmatory testing. We did find a high prevalence of reported direct contact with wildlife blood as well as triatomine and other arthropod disease vectors. This large-scale screening program represents a novel approach to better understand the vector-borne disease risk in this unique population.

Chagas disease, caused by the protozoan parasite *Trypanosoma cruzi*, remains one of the most significant neglected tropical diseases affecting the Americas. It is estimated that six to eight million people are infected with this parasite worldwide, with 238,091 infected individuals living in the United States.[1–4] This disease causes progressive cardiac damage in about 30% of infected people, resulting in significant morbidity and mortality.[5]

The initial stages of Chagas disease are typically asymptomatic, making it difficult to detect cases early when treatment is more effective.[6] Symptomatic cardiac disease does not usually develop until decades after infection. Therefore, identifying high-risk populations is important for understanding Chagas disease transmission and directing public health resources. We recently hypothesized that Texas hunters may be at an elevated risk for contracting Chagas disease.[7–11] Hunters spend an extended amount of time outdoors in areas where sylvatic transmission of Chagas is likely, tend to stay overnight in substandard structures, and have frequent contact with potential mammalian reservoirs.[7] All of these activities could place this population at an elevated risk for contracting Chagas disease. To assess their risk of exposure to *T. cruzi* and the triatomine vector, known locally as "kissing bugs" or "conenose bugs" (*Triatoma* spp.), we initiated a statewide screening program in Texas.

From August 2016 to May 2018, we invited study participants with a history of hunting in the state of Texas to participate in our Chagas screening program. Recruitment was conducted at public hunting areas, community events, and hunting expositions across the state. Working in collaboration with Texas Parks and Wildlife, we recruited participants from deer and feral hog hunts open to the public in 10 wildlife management areas, state parks, or the state's national areas. We also recruited from nine hunting expositions and seven community events (Figure 1A).

For each study participant who provided informed consent or had a parent or legal guardian who provided consent if younger than 18 years, we obtained a blood sample via venipuncture or finger stick and conducted an interview to obtain demographic information, hunting history, and a history of vector exposures. At the time of enrollment, the Chagas Stat-Pak rapid assay (Chembio, Medford, NY) was used as a point-of-care test to obtain a preliminary result. If the participant allowed a full blood sample to be taken, an additional Hemagen Chagas Kit EIA (Hemagen Diagnostics, Columbia, MD) was later performed in our laboratory at Baylor College of Medicine. Specimens determined to be positive by Chagas Stat-Pak or Hemagen Chagas EIA were sent to the CDC, Division of Parasitic Diseases and Malaria, Parasitic Disease Reference Diagnostic Laboratory for confirmatory testing by Chagatest ELISA (Wiener Lab, Rossario, Argentina). All assays used in this study are commercially available and have been used previously in epidemiologic studies of Chagas disease.[12,13] This study was approved by the Institutional Review Board at Baylor College of Medicine (H-35471).

A total of 885 individuals, self-reported as hunters, participated in this study, representing 409 unique residential zip codes (Figure 1B). The cohort was predominately male (81%), and white (95.6%), non-Hispanic (86%), with an average age of 48 years (Table 1). We believe this cohort is demographically representative of the 1.1 million Texans who hold a hunting license in the state, which comprises 87.6% men and 85% Caucasians, with the majority aged between 35 and 55 years (53%).[14]

Of the hunters who participated in the screening, we obtained surveys from 855 (96.6%) participants. Our cohort reported an average of 31 years hunting (range, 1–75 years), with the majority of participants typically taking 2- to 3-day-long hunting trips (512/844). Of those who reported staying overnight for a hunting trip, the majority reported sleeping in a cabin (392/683), whereas others reported staying in tents (236/683) or campers (243/683). Of concern, 78 participants

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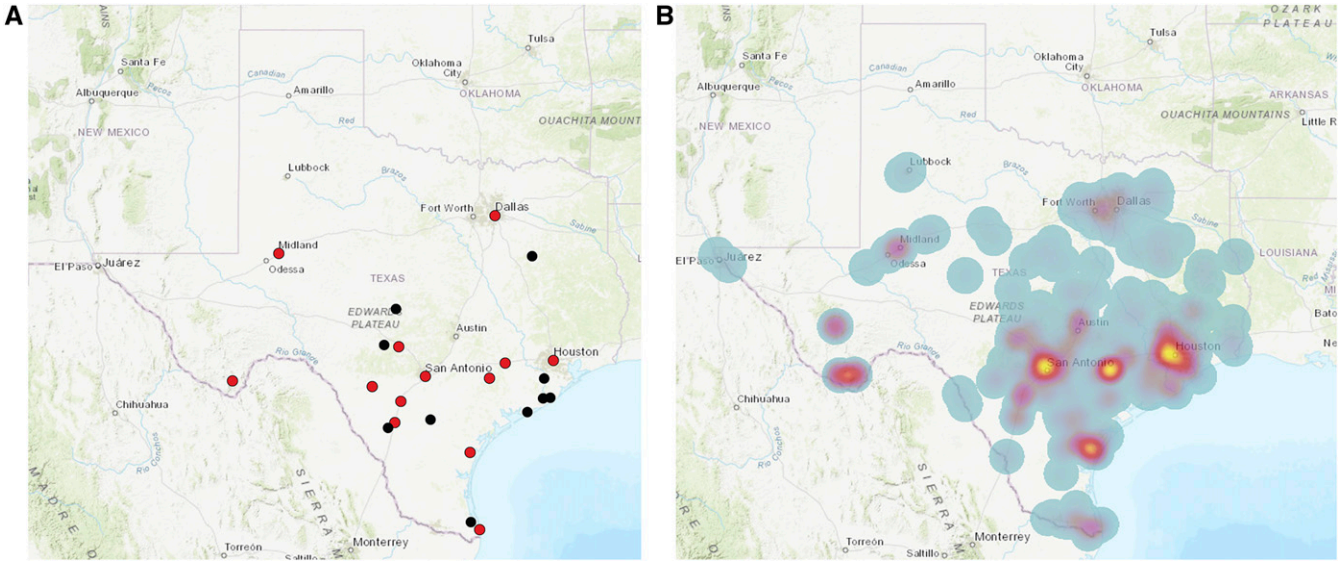

FIGURE 1. Participant recruitment. Map (**A**) depicts the 23 locations where recruitment events were held for this study (some locations had multiple events). Black dots represent a public hunting recruitment was conducted. Red dots represent a hunting expo or community event where recruitment was conducted. Map (**B**) depicts a heat map of residential zip codes reported by hunters enrolled in this study. This figure appears in color at www.ajtmh.org.

reported sleeping outdoors with no shelter, elevating their risk of exposure to triatomines because of nocturnal feeding and CO_2-seeking behaviors.[2] In addition, almost half of these hunters (297/601) reported seeing insects where they slept while hunting. Although they did not identify triatomines directly, the evidence of insect infestations in their lodging suggests the potential for triatomines to infiltrate the structures (Table 2).

The majority of our cohort reported hunting white-tailed deer (*Odocoileus virginianus*; 799/855). In addition, participants reported hunting feral hogs (*Sus scrofa*; 632/855), small mammals (242/855), birds (447/855), fish (451/855), opossums (*Didelphimorphia*; 33/855), and armadillos (*Dasypodidae*; 32/855). Almost all reported field-dressing or processing the animals themselves (746/855), with a concerning majority (432/652) of the cohort reporting rarely or never using gloves when field-dressing, which allows for direct contact with blood and organs. We believe this lack of barrier protection use is concerning, as 23 mammalian species serve as reservoirs for Chagas disease in Texas, including white-tailed deer, feral hogs, opossums, and armadillos.[9,15,16] Without proper protection during the field-dressing process, there is a potential for blood-borne

TABLE 1
Demographics of hunter participants, n = 885

	N	%
Gender		
Male	714	81
Female	171	19
Age (years)		
0–18	26	3
19–40	256	29
41–60	372	42
60+	224	25
Not listed	7	1
Race		
White	846	95.6
Asian	3	< 1
Black	10	1
Other/not listed	26	3
Ethnicity		
Hispanic	123	14

TABLE 2
Hunting practices and vector exposures

Hunting practices	
Average hunting years (range)	31 (1–75)
Average hunting trip, n/total	
1 day	188/844
2–3 days	512/844
1+ week	145/844
Use a hunting structure	694/854
Box stand	495/694
Tree stand	288/694
Ground blind	430/694
Stay overnight while hunting	683/855
Open air	78/683
Hotel	26/683
Cabin	392/683
Tent	236/683
Camper	243/683
Other	41/683
See insects where you sleep	297/601
Field-dress animal	746/855
Often or always wear gloves while field-dressing	220/746
Vector exposure	
Seen triatomines "kissing bugs"	540/839
Inside home	83/540
Outside home	284/540
While hunting	233/540
Bitten by triatomines	32/855
Bitten by mosquitos while hunting	
Often/always	578/855
Bitten by ticks while hunting	
Often/always	118/855
Insect repellent use while hunting	
Never/rarely	495/855

Reported data concerning hunting practices and vector exposure from the study participants who completed all or part of our survey (n = 855).

transmission if the hunter has any cuts or abrasions on the hand (Table 2).

When shown pictures of triatomines and resin-embedded *Triatoma gerstaeckeri* and *Triatoma sanguisuga* as visual aids, the majority of hunters reported having seen triatomines before (549/851). The hunters reported predominately seeing them outside their residential home and hunting lodge. Of concern, 83 participants from the cohort reported seeing them in their home, indicating the potential for domestic infestation. From our hunting cohort, 32 participants reported a triatomine bite history. In addition to triatomine exposure, this cohort reported a high prevalence of frequent mosquito (578/855) and tick (118/855) bites while hunting. Unfortunately, insect repellant use was not common among this cohort, with most participants (495/855) reporting rarely or never applying repellent while hunting. With such frequent exposure to these disease vectors, it is important to educate hunters and other outdoor enthusiasts to apply appropriate repellents to prevent vector-borne disease transmission (Table 2).

Among all participants, 18 had positive results for *T. cruzi* infection on the initial rapid test (2%). From our cohort, 71% (624/885) allowed us to take a full blood sample for additional testing, including all 18 participants who initially screened positive. The Hemagen EIA indicated one positive and one indeterminate result of the 624 tested. None of the rapid test–positive individuals were also positive by Hemagen EIA. All 20 samples of the positive and indeterminate serum specimens (18 positive by Stat-Pak, one positive by EIA, and one indeterminate by EIA) were sent to CDC for confirmatory Weiner EIA. CDC confirmatory testing found none of the 20 samples positive. The current guidelines for diagnosis of Chagas disease requires two or more positive tests to confirm a case; therefore, we believe these individuals represent false-positive results, which is expected considering the reported specificity of Chagas Stat-Pak is 97%.[17,18]

Although we likely did not find evidence of any cases of Chagas disease within this cohort of Texas hunters, we did find evidence of vector exposure and the potential for transmission. We also identified a gap in knowledge about Chagas disease, with only 40% (347/855) of participants reporting having heard of the disease before enrollment in the study. Most hunters reported staying overnight for their hunting trip, often in substandard or insect-infested lodging. Almost all hunters reported field-dressing wildlife carcasses, most of which are known reservoirs for *T. cruzi*, and doing so without gloves, introducing the potential for blood-borne transmission. Finally, a high proportion of this cohort reported having seen triatomines and some reported previous bites by the vector, indicating hunters are in areas of active sylvatic transmission cycles, and not using appropriate insect repellants.

This study does have some noteworthy limitations. The data collected from these surveys were self-reported and, as such, subject to response bias. When asking participants about triatomine exposure, we cannot rule out that they are misidentifying a "look-alike" insect. We believe that by showing participants several examples of local species in pictures and resin blocks, we have reduced the possibility of misclassification. We cannot rule out the potential for a false-negative diagnosis in this cohort. We believe our testing algorithm was designed to limit the probability of this occurring, as our initial diagnostic, Chagas Stat-Pak, has previously been found to have high sensitivity, and we encouraged individuals to allow for a second diagnostic regardless of the initial testing results.[12] Although we have followed the standard serologic diagnostic protocol, the low potential for misdiagnosis exists. Finally, our sample size may be too small to accurately detect the prevalence of Chagas disease in this population, as only one in 6,500 blood donors in the state is identified as Chagas positive.[19,20] Larger surveillance efforts are necessary to truly determine the prevalence of disease in this population.

This large-scale screening program represents a novel approach to better understand Chagas disease transmission and vector exposure in this high-risk population in the Southern United States. The present study identified a risk of triatomine and other vector exposures during activities associated with hunting. Most significantly, this study illustrates the significant knowledge gap surrounding Chagas disease and the steps hunters can take to prevent becoming infected. We believe these findings highlight the importance of enhanced public health campaigns targeting unique populations, such as hunters, who may be at an increased exposure risk in Texas.

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