Call to action: A literature review of Chagas disease risk in California 1916–2018

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Human Chagas disease (CD), caused by the Trypanosoma cruzi infection, is considered nonendemic in the United States of America [https://www.cdc.gov/parasites/chagas/gen_info/detailed.html#intro; consulted March 29, 2020], assuming that this chronic affection’s epidemiology is different from that of Latin American countries. The attention is mostly focused on blood bank screening, organ donation, and vertical (mother to child) transmission [1]. This approach can overlook the potential for autochthonous transmission of T. cruzi, particularly in the light of a recent acknowledgment about the role that vectorial transmission may have on the CD in the USA. A low awareness among physicians about CD risk besides its migratory origin can contribute to an existing underreporting rate, thus masking the accurate estimation of CD burden in the USA [2].

Cases of autochthonous infection in the USA are not accurately tracked since it is only mandatory to report it in seven states, i.e., Arizona, Arkansas, Louisiana, Mississippi, Tennessee, Texas, and Massachusetts [3]. However, as it occurs in Latin America, where the index of suspicion is much higher, acute T. cruzi infections in immunocompetent individuals can pass undiagnosed and undetected among residents [4]. In the USA, 238,091 cases are estimated as of 2012 [5]. This analysis highlighted the role of Latin immigrants in the CD burden, with California being the state with the highest estimated number of cases.

Although imported CD cases are undoubtedly a matter of concern, there are also environmental conditions leading to autochthonous infections [6]. New encounters between humans and triatomine bugs are often associated with the destruction of or invasion into vertebrate hosts’ habitats, compromised housing structures, or both. Disruption of host burrows provokes the bugs to seek new refugees, and their attraction to artificial light often leads them to nearby human dwellings [7]. Multiple publications have highlighted the southern USA as an area where autochthonous infection occurs, mainly because of the high proportion of impoverished residents living in substandard housing infested by triatomines [7–10].

It is essential to improve our knowledge of T. cruzi infection risk components because there are parasite reservoirs among wildlife species and vectors living in contact with humans [11]. This is especially found in less-studied regions such as California, where the epidemiological, parasitological, and entomological patterns of T. cruzi transmission might resemble those of other endemic areas. Surveillance of infection prevalence among local populations of Triatominae is critical for accurate assessment of the public health risk. We attempt to contribute to this with an extensive historical literature review of records of autochthonous T. cruzi and human-related data for CD in California. This method of review provides a contemporary account of this topic’s breadth of knowledge. There has been no recent review of this theme at
the state level to the best of our knowledge, as has already been conducted in some other states, such as Texas [12].

We summarized a historical account of triatomines reports, infection with *T. cruzi* in triatomines, mammals and humans (CD), and human-triatomine interaction for California counties. We found 62 articles published between 1916 and 2018 encompassing 35 countries (Table 1), mostly from the greater Los Angeles area, metropolitan San Diego, Sierra Nevada’s foothills, and the Morongo Basin (Fig 1A and 1B).

Between 1916 and 1930, *T. cruzi* was reported for the first time in the USA in San Diego County. The Los Angeles and San Diego counties account for up to 1,000 and 2,500 records, respectively. The *T. cruzi* infection prevalence was estimated for 34 of 56 localities in 13 counties (Fig 1C), ranging from 9% to 100% among triatomines and 0.62% to 100% among six wild mammals and dogs (Tables 2 and 3). The most abundant triatomine species in California is *Triatoma protracta* (98% of the 4,951 records), followed by *Triatoma rubida* and *Paratriatoma hirsuta*.

The first report of domestic incidence was recorded in the 1940s. In 38.8% of the publications reporting collection site for triatomines (19/49), at least one was collected inside human habitation. Domestic triatomine incidence was associated with dispersion from the vicinity of residences in semirural, canyon, or mountain-foothill areas (involved removal of mammal hosts and triatomine nest); during the monsoon, houselights are attractive to triatomines, especially while mating and/or seeking blood-meals.

Twenty-two publications reported 164 triatomine bites and ensuing anaphylactic reactions among residents of 11 California counties (Fig 1D), 80% of them taking place inside dwellings. Tuolumne and Los Angeles counties reported the largest number of cases. At least four patients with Romaña signs have been reported since 1964.

In publications around the 1950s, the bulk of domestic triatomines reports and human exposure came from residents’ testimonies, from Kern, Riverside, Fresno, and San Diego counties, and from descriptions of clinical cases (S1 Text). Although in California, CD is not mandatory to report. In 2008 and 2010, the Californian Vector-Borne Department Section recorded reports of vector inside homes and bites. A different perspective of this interaction are the 24 distinct common names in English, Spanish, and a Native American language for the insect found across the literature. This might suggest it’s a more common interaction than previously thought. This has been indicated by ethno-entomology studies and reports among indigenous peoples within the CD endemic areas (Table 4) [38].

| Decade | % Publications | # Triatomine collected | Counties of first report |
|--------|----------------|------------------------|--------------------------|
| 1930   | 5              | 652                    | San Diego, Los Angeles, Inyo, Kern |
| 1940   | 7              | 289                    | Fresno, Riverside, Amador, Madera, Stanislaus, Tulare |
| 1950   | 12             | 731                    | San Bernardino |
| 1960   | 14             | 2,427                  | Ventura, Butte, Mariposa, Mendocino, Monterey, Napa, Contra Costa, El Dorado, Lake, Yolo, Alameda, Orange, Nevada, Placer, Santa Barbara, Santa Cruz, Siskiyou, Tehama, San Luis Obispo |
| 1970   | 6              | 353                    | Imperial, San Benito |
| 1980   | 7              | 110                    | Tuolumne, – |
| 1990   | 1              | 0                      | – |
| 2000   | 3              | 191                    | Calaveras, – |
| 2010   | 7              | 137                    | – |

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Research on human-triatomine interaction in California involved two surveys conducted 50 years apart. The State Department of Health conducted a study in 1962 in Mariposa and Tuolumne counties that recorded more than 101 bite cases. In 2012, Los Angeles’ residents reported bites resembling the swelling (called Chagoma) produced by triatomines, and rural residents in Santa Barbara were found with immunoglobulin G (IgG) against the \textit{T. protracta} saliva. Along with this, human blood-meals have been found in free-roaming triatomines [47].

In 1982, the first autochthonous human case of CD was reported for California in Tuolumne county: a 50-year-old woman from Lake Don Pedro [48]. Thereafter a broad serological survey, the only type in the states’ history, was conducted among three groups of residents, revealing antibodies in 2.5% to 0.7% of the population. The second case was reported in Simi Valley in 2016 and discovered through a routine screening test in blood-donation, a 19-year-old white male, locally born and raised, with no acknowledged bite but who had presumably been exposed during outdoor activities [49].
This review of the autochthonous transmission of *T. cruzi* in California is the first one in more than 50 years. A temporal analysis of the publications shows an early scientific effort to compare some endemic areas; 80% of the articles were published before the early 1980s (Table 1). Amid the current debate about autochthonous transmission in the Southern USA, evidence of an ongoing domestic cycle and *T. cruzi* human infection has been found [7,9]. Our review shows evidence that the current assessment of public health risk among California residents is mostly based on outdated and is nonpublicly acknowledged.

Regarding the low number of human CD cases in California, our literature review shed light on a set of circumstances that have difficulted the report of official autochthonous cases. First, human-triatomine interaction was assessed in terms of risk of anaphylaxis—common in the Southwest—but not for *T. cruzi* transmission. Only one bite case was followed up by a screen test. A triatomine bite is nonreactive among 85% to 95% of the cases, reducing the chances of seeking medical care and suspicion of *T. cruzi* infection [50]. Secondly, there is no routine screening program at the primary care level in California, and mandatory blood-

**Table 2. Prevalence of *T. cruzi* infection among triatomines per county.**

| County    | No. of specimens collected | No. of specimens analyzed | No. (%) Positive for *T. cruzi* infection | References |
|-----------|----------------------------|----------------------------|------------------------------------------|------------|
| Kern      | 1                          | 1                          | 1 (100)                                  | [13]       |
| Tulare    | 2                          | 2                          | 2 (100)                                  | [14,15]    |
| Calaveras | 44                         | 44                         | 29 (65.9)                                | [16,17,18] |
| Madera    | 125                        | 77                         | 39 (50.6)                                | [14,19,20] |
| Butte     | 4                          | 4                          | 2 (50)                                   | [13]       |
| Los Angeles | 2,005                     | 1,679                      | 576 (34.3)                               | [13,17,19,20,21,22,23,25,26] |
| San Diego | 1,027                      | 477                        | 157 (32.0)                               | [6,21,27]  |
| Fresno    | 4                          | 4                          | 1 (25)                                   | [27]       |
| San Benito | 9                          | 9                          | 2 (22.2)                                 | [28]       |
| Riverside | 18                         | 18                         | 4 (22.2)                                 | [29]       |
| Stanislaus | 6                          | 6                          | 1 (16.7)                                 | [14]       |
| San Bernardino | 398                       | 355                        | 54 (15.2)                                | [30]       |

**Table 3. Natural *T. cruzi* infection among mammals, according to the county.**

| Species                              | County       | Total no. Tested | No. (%) Positive for *T. cruzi* infection | Assay type (sample or specific assay) | Site of collection                                      | Reference |
|--------------------------------------|--------------|-----------------|------------------------------------------|---------------------------------------|--------------------------------------------------------|-----------|
| Skunk (*Mephitis mephitis*)          | Los Angeles  | 1               | 1 (100)                                  | Serology and histology                | Peri-urban (Griffith Park)                              | [31]      |
| Wood-rat *Neotoma* spp. Big-eared woodrat | Los Angeles  | 99              | 9 (9)                                    | Xenodiagnosis and blood smear         | Wild, Peri-urban                                        | [32] [28] [15] |
| San Diego                           |              | 228             | 2 (0.88)                                 | Blood smear (from the heart)          | Wild                                                   | [33] [34] |
| Calaveras                           |              | 49              | 7 (14.3)                                 | PCR assays                            | Wild (within private property) Microhabitat on private property | [6]       |
| Gilbert white-footed mouse (Peromyscus truei gilberti) | Madera      | 484             | 3 (0.62)                                 | Xenodiagnosis, and blood smear        | Wild                                                   | [35] [36] |
| Pinon mouse (Peromyscus truei montipinoris) | Los Angeles | 228             | 12 (5.3)                                 | Xenodiagnosis                         | Peri-urban                                             | [15]      |
| Dog (*Canis familiaris*)            | Tuolumne     | 17              | 6 (35.3)                                 | CF Titers and Culture (blood) (1982) 4 seropositive dogs: Antibodies CF Titers and IIF (1984) | Domestic                                              | [37]      |
donor screening is not adequate for capturing \textit{T. cruzi} infection among both Latino immigrants and residents [1]. Current efforts in this sense target Latino immigrants. Therefore, as potential autochthonous cases, individuals might not meet risk criteria about the country of birth, ethnicity, and a history of travel to an endemic country. The lack of specifically assessed locally acquired infection and large-scale serological surveys might have failed to detect autochthonous cases. Lastly, physicians might be unaware of the local risk and fail to encourage patients to get tested [2]. Health providers have underestimated CD cases because they believe it to be “a South American problem,” leading to misdiagnosis [51]. In patients’ cases, they may decline to seek healthcare if feeling healthy during the CD indeterminate phase (non-symptomatic), when having limited access to healthcare, i.e., among the low-income and homeless individuals, or when choosing to avoid a perceived stigma [52]. In the USA, mainstream stereotypes are that CD is a “tropical exotic” disease prevalent among so-called “illegal aliens” and it is associated with poverty.

Compared to what occurs in Latin America, a generally higher housing standard in the USA has been a main contributor for the low incidence of reports of domestic triatomines and human CD [47]. However, both the historical domestic incidence and recent data documented here suggest that residences might harbor vector colonies [53]. While triatominoviviposition, nymphal development, and \textit{T. cruzi} infection may occur outdoors, we believe that \textit{T. cruzi} transmission in California might have some similarities with Texas, and Mexican endemic triatomines are not domestic but disperse from surrounding areas. Human-triatomine interaction also occurs outdoors due to the free-roaming vector that feeds on human hosts given the opportunity [7,10]. In California, outdoor activities within forests and natural parks are widely popular, for instance, during 2018, a total of 269,055 hunting licenses were granted, and campsite attendance reached 7,265,525 overnight stays.

Socioenvironmetal changes of the last five decades in California have not been followed by research on their effects on human-triatomine interaction and \textit{T. cruzi} transmission. Loss of habitat and human settlements (and increasing numbers of pets) have led to an increasing encroachment upon the natural habitat of triatomines and their mammal hosts. This might raise the chances of triatomin domestic incidence due to their flexibility in habitat and host requirements, including dogs and other mammals (rodents, opossums, raccoons, etc.). Examples of \textit{Triatoma sanguisuga} in Louisiana came after the disruption of hurricane Katrina; there was a change of infestations in human dwellings [53].

County-level maps of reports only partially reflect the \textit{T. cruzi} distribution in California. This is due to the scarcity/absence of records in some areas and early discovery of the
association triatomine-woodrat that might be biased to the field research. An ecological niche modeling approach of the geographic distribution of vector species indicates favorable host habitat in many unsurveyed regions of California [54].

Our review in California highlights that a critical and accurate assessment of the public health risk for *T. cruzi* and CD needs research/intervention on the:

1. Spatial modeling of pattern occurrences of triatomine and *T. cruzi* infection for further robust analysis on habitat suitability and risk due to socioenvironmental changes;
2. Dynamics and mechanisms of transmission: spatial variation of triatomine activity, infection levels and their reliance on humans-blood, dynamics of dispersal flights and free-roaming triatomines feeding habits;
3. Identification of sylvatic, synanthropic, and domestic (especially dogs) animal blood-sources and determination of infection variability;
4. Identification of the *T. cruzi* circulating strains and an analysis of the parasite’s genetic variation;
5. Large-scale systematic programs of active surveillance, rigorous population-based data collection, and comprehensive assessment to determine infection prevalence and morbidity to identify factors that might inform policy and program-driven actions, especially among the vulnerable (impoverished residents living in substandard housing);
6. Improvement of local knowledge local about epidemiology and ecology and the criteria for public health promotion to raise awareness among residents, physicians, and clinicians;
7. Active screening of heart failure patients, hunters/campers, and pregnant women; and
8. Continuing medical education programs on diagnosis and treatment among physicians.

**Supporting information**

S1 Text. Domestic and peri-domestic reports of human bites and human exposure to vectors.

(DOCX)

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**References**

1. Bern C, Messenger LA, Whitman JD, Maguire JH. Chagas Disease in the United States: a Public Health Approach. Clin Microbiol Rev. 2019; 27; 33(1):e00023–19. https://doi.org/10.1128/CMR.00023-19 PMID: 31776135
2. Stimpert KK, Montgomery SP. Physician awareness of Chagas disease, USA. Emerg Infect Dis. 2010; 16(5): 871–872. https://doi.org/10.3201/eid1605.091440 PMID: 20409389
3. Bennett C, Straily A, Haselow D, Weinstein S, Taffner R, Yaglom H, et al. Chagas Disease Surveillance Activities—Seven States, 2017. MMWR Morb Mortal Wkly Rep. 2018; 67: 738–741. https://doi.org/10.15585/mmwr.mm6726a2 PMID: 29975678
4. Castro Y, Marcus R. Epidemiology of Chagas disease in the USA: high-risk patient populations for screening. Curr Trop Med Rep. 2019; 6: 8–12.
5. Manne-Goehler J, Chukwuemeka AU, Montgomery SP, Wirtz VJ. Estimating the burden of Chagas Disease in the United States. PLoS Negl Trop Dis. 2016; 10: e0005033. https://doi.org/10.1371/journal.pntd.0005033 PMID: 27820837

6. Shender L, Lewis M, Rejmanek D, Mazet J. Molecular diversity of Trypanosoma cruzi detected in the vector Triatoma protracta from California, USA. PLoS Negl Trop Dis. 2016a; 10: e0004291. https://doi.org/10.1371/journal.pntd.0004291 PMID: 26797311

7. Lynn MK, Bossak BH, Sandifer PA, Watson A, Nolan MS. Contemporary autochthonous human Chagas disease in the USA. Acta Trop. 2020; 205: 105361. https://doi.org/10.1016/j.actatropica.2020.105361 PMID: 32006523

8. Garcia MN, Aguilar D, Gorchakov R, Rossmann SN, Montgomery SP, Rivera H, et al. Case report: evidence of autochthonous Chagas disease in southeaster Texas. Am J Trop Med Hyg. 2015; 92: 325–330. https://doi.org/10.4269/ajtmh.14-0238 PMID: 25371187

9. Curtis-Robles R, Zecca IB, Roman-Cruz V, Carabajal ES, Auckland LD, Flores I, et al. Trypanosoma cruzi (Agent of Chagas Disease) in Sympatric Human and Dog Populations in "Colonias" of the Lower Rio Grande Valley of Texas. Am J Trop Med Hyg. 2017; 96(4): 805–814. https://doi.org/10.4269/ajtmh.16-0789 PMID: 28167589

10. Beard CB, Pye G, Steurer FJ, Rodriguez R, Campman R, Peterson AT, et al. Chagas disease in a domestic transmission cycle, southern Texas, USA. Emerg Infect Dis. 2003; 9: 103–105. https://doi.org/10.3201/eid0901.020217 PMID: 12533289

11. Georgieva AY, Gordon ERL, Weirauch C. Sylvatic host associations of Triatomineae and implication for Chagas disease reservoirs: a review and new host records based on archival specimens. PeerJ. 2017; 5: e3826. https://doi.org/10.7717/peerj.3826 PMID: 28948106

12. Garcia MN, Woc-Colburn L, Aguilar D, Hotez PJ, Murray KO. Historical Perspectives on the Epidemiology of Human Chagas Disease in Texas and Recommendations for Enhanced Understanding of Clinical Chagas Disease in the Southern United States. PLoS Negl Trop Dis. 2015; 9: e0003981. https://doi.org/10.1371/journal.pntd.0003981 PMID: 26540273

13. Wood SF, Wood FD. Nocturnal aggregation and invasion of homes in southern California by insect vectors of Chagas’ disease. J Econ Entomol. 1964b; 57: 775–776.

14. Wood SF. The distribution of California insect vectors harboring Trypanosoma cruzi Chagas. Bull S Calif Acad Sci. 1950b; 49(3): 98–100.

15. Wood S. Trypanosoma cruzi: new foci of enzootic Chagas’ disease in California. Exp Parasitol. 1975f; 38: 153–160. https://doi.org/10.1016/0014-4894(75)9017-x PMID: 809291

16. Stevens L, Dom PL, Hobson J, de la Rua NM, Lucero DE, Klotz JH, et al. Vector blood meals and Trypanosoma cruzi (Agent of Chagas Disease) in sympatric human and dog populations of Los Angeles, California. Pan-Pac Entomol. 1952a; 28(1): 58.

17. Hwang WS, Guanyang Z, Maslov D, Weirauch C. Short report: infection rates of Triatoma protracta (Uhler) with Trypanosoma cruzi in Southern California and molecular identification of trypanosomes. Am J Trop Med Hyg. 2012; 86: 646–649. https://doi.org/10.4269/ajtmh.2012.10-0167 PMID: 22465936

18. Klotz SA, Dom PL, Klotz JH, Pinnas JL, Weirauch C, Kurtz JR, et al. Feeding behavior of triatomines from the southwestern United States: An update on potential risk for transmission of Chagas Disease. Acta Trop. 2009; 111: 114–118. https://doi.org/10.1016/j.actatropica.2009.03.003 PMID: 19524078

19. Mehringer PJ, Wood SF. A resampling of wood rat houses and human habitations in Griffith Park, Los Angeles, for Triatoma protracta and Trypanosoma cruzi. Bull S Calif Acad Sci. 1958; 52: 46–56.

20. Ryckman RE. Triatoma protracta infected with Trypanosoma cruzi at Riverside, California (Hemiptera: Reduviidae). Pan-Pac Entomol. 1952a; 28(1): 58.

21. Vector-Borne Sector, California Department of Public Health; 2018. Database: Triatoma submitted for testing. Available from requesting VBS California Department of Public Health.

22. Sjogren RD, Ryckman RE. Epizootiology of Trypanosoma cruzi in southwestern North America. Part VIII: Nocturnal flights of Triatoma protracta (Uhler) as indicated by collections at black light traps (Hemiptera: Reduviidae: Triatominae). J Med Entomol. 1966; 3: 81–92. https://doi.org/10.1093/jmedent/3.1.81 PMID: 5941571

23. Wood SF. Conenose bug annoyance in Griffith Park in 1958. Bull So Calif Acad Sci. 1960b; 59: 50–52.

24. Augustson GF, Wood SF. Notes on Californian mammals ecto-Parasites from the Sierra Nevada Hills of Madera County. Bull So Calif Acad Sci. 1953; 52: 46–56.

25. Wood SF. Conenose bug annoyance and Trypanosoma cruzi Chagas in Griffith Park, Los Angeles. Bull So Calif Acad Sci. 1953; 52(3): 105–109.

26. Wood S. An additional California locality for Trypanosoma cruzi Chagas in the Western Cone-Nosed Bug, Triatoma protracta (Uhler). J Parasitol. 1944a; 30(3): 199.
27. Wood SF. Observations on vectors of Chagas’ disease in the United States. I. California. Bull So Calif Acad Sci. 1942c; 41: 61–69.
28. Wood SF, Wood FD. Ecological relationships of Triatoma protracta (Uhler) in Griffith Park, Los Angeles, California. Pac Insects. 1967; 9: 537–550.
29. Wood SF. Bug annoyance in the Sierra Nevada foothills of California. Bull So Calif Acad Sci. 1951a; 50: 106–112.
30. Wood SF, Anderson RC. Conenose bugs triatoma) visit unoccupied boy’s camp in Los Angeles. J Med Entomol. 1965; 1: 347–348. https://doi.org/10.1093/jmedent/1.4.347 PMID: 14280486
31. Ryan CP, Hughes E, Howard EB. American Trypanosomiasis (Chagas’ Disease) in a striped skunk. J Wildl Dis. 1985; 21: 175–178. https://doi.org/10.7589/0090-3558-21.2.175 PMID: 3923215
32. Wood SD, Hughes H. A mammal host of Trypanosoma cruzi Chagas in Griffin Park, Los Angeles, California. Bull So Calif Acad Sci. 1953; 52: 103–104.
33. Wood FD. Natural and experimental infection of Triatoma protracta Uhler and mammals in California with American human trypanosomiasis. Am Jour Trop Med. 1934a; 14: 497–517.
34. Wood SD, Wood FD. New locations for Chagas’ trypanosome in California. Bull So Calif Acad Sci. 1964a; 63: 104–111.
35. Wood SF. Mammal blood parasite records from southwestern United States and Mexico. J Parasitol. 1952a; 38: 85–86.
36. Wood SF. Blood parasites of mammals of the California Sierra Nevada foothills, with special reference to Trypanosoma cruzi and Hepatozoon leptosomata sp. n. Bull So Calif Acad Sci. 1962; 61: 161–176.
37. Navin TR, Roberto RR, Juranek DD, Limpakarnjanarat K, Mortenson EW, Clover JR, et al. Human and sylvatic Trypanosoma cruzi infection in California. AJPH. 1985; 75: 366–369. https://doi.org/10.2105/ajph.75.4.366 PMID: 3919598
38. Costa-Neto EM. The use of insects in folk medicine in the State of Bahia, Northeastern Brazil, with notes on insects reports elsewhere in Brazilian folk medicine. Hum Ecol. 2002; 30: 245–263.
39. Kofoid CA, McCulloh I. On Trypanosoma triatomae, a new flagellate from a hemipteran bug from the nests of the wood rat Neotoma fuscipes. Univ California Publ Zool. 1916; 16: 113–126.
40. Kofoid y Donat 1933b. South American Trypanosomiasis of the human type—occurrence in mammals in the United States. California and Western Medicine. 1933b; 38: 245–249.
41. Wood SD, Wood FD. New locations for Chagas’ trypanosome in California. Bull So Calif Acad Sci. 1964a; 63: 104–111.
42. Wood SF. Conenose bug (Triatoma) annoyance and Trypanosoma cruzi in southwestern national monuments. Bull So Calif Acad Sci. 1953b; 52: 57–60.
43. Walsh JD, Jones JP. Public health significance of the cone-nosed bug, Triatoma protracta (Uhler), in the Sierra Nevada foothills of California. Calif Vector Views. 1962; 3: 33–38.
44. Swezey R. Kissing bug bite in Los Angeles. Arch Intern. 1963; 112: 977–980. https://doi.org/10.1001/archinte.1963.03860060189021 PMID: 14065009
45. Scott K. Ken Scott catches the “kissing bug”. PCO News. 1963; 23: 17.
46. Dolhun EP, Antes AW. Case report: a case of cardboard boxes likely facilitating the biting of a patient by Trypanosoma cruzi-infected triatomine bugs. Am J Trop Med Hyg. 2016; 95: 1115–1157. https://doi.org/10.4269/ajtmh.16-0455 PMID: 27601526
47. Klotz SA, Schmidt JO, Dom PL, Ivanyi C, Sullivan KR, Stevens L. Free-roaming kissing bugs, vectors of Chagas disease, feed often on humans in the Southwest. Am J Med. 2014b; 127: 421–426. https://doi.org/10.1016/j.amjmed.2013.12.017 PMID: 24398362
48. Schiffler R, Mansur G, Navin T, Limpakarnjanarat K. Indigenous Chagas’ disease (American trypanosomiasis) in California. JAMA. 1984; 251: 2983–2984. PMID: 6425516
49. Hernandez S, Flores CA, Viana GM, Sanchez DR, Traina MI, Meymandi SK. Autochthonous transmission of Trypanosoma cruzi in Southern California. Open Forum Infect. 2016; 20: https://doi.org/10.1093/ofid/ofw227 PMID: 28018928
50. Wood SF. Reaction of man to the feeding of Triatoma protracta (Hemiptera: Reduviidae). National Pest Control Operator News. 1975a; 35: 19–21.
51. Friedman S, Parks E, Yasmin S. Hidden threat: the kissing bug and Chagas disease. NBC 5 Dallas-Fort Worth. 2016 [Cited 2018 Jan 27]. Available from: http://www.nbcdfw.com/investigations/Hidden-Threat-The-Kissing-Bug-and-Chagas-Disease 345192802.html
52. Inger B, Garcia MN, Leon J, Murray KO. Chagas disease Knowledge and Risk Behaviors of the home-less population in Houston, TX. J Racial Ethn Health Disparities. 2018; 5: 229–234. https://doi.org/10.1007/s40615-017-0362-0 PMID: 28567616
53. Dorn P, Pernicario L, Yabsley M, Roellig D, Balsamo G, Diaz J. Autochthonous transmission of Trypanosoma cruzi, Louisiana. Emerg Infect Dis. 2007; 13: 605–607. https://doi.org/10.3201/eid1304.061002 PMID: 17553277

54. Ibarra-Cerdeña CN, Sanchez-Cordero V, Townsend P Ramsey JM. Ecology of North American triatominae. Acta Trop. 2009; 110: 178–186. https://doi.org/10.1016/j.actatropica.2008.11.012 PMID: 19084490