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Epidemiological Surveillance of Chagas Disease in São Paulo State: Community Participation and Vectors Situation

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Abstract

The Chagas Disease Control program in the State of São Paulo includes community participation in entomological surveillance with the referral of suspected insects, which allows monitoring the situation. This study aims at evaluating epidemiological surveillance of Chagas disease in the state emphasizing community participation. Information from the period between 1990 and 2021 has been analyzed. From 1990 to 2003 entomological surveillance efforts included active search in locations according to infestation and since then community participation prevails through notification of triatomines by residents. Insects collected are identified and examined to check for *Trypanosoma cruzi* infection. Through community participation 46,129 notifications of triatomines were forwarded, out of which 27,1% were positive after checking. Within the period 230,303 triatomines were collected predominating *Triatoma sordida* (74.9%). In the last quadrennium *Rhodnius neglectus* species was the most collected one. Higher levels of natural infection were observed for *Triatoma tibiamaculata* (18.6%), followed by *Panstrongylus megistus* (9.4%) that has colonized urban areas. Serology run in human was positive in 1.4% of samples. Entomological surveillance with community participation has been effective. The colonization of triatomines in urban centers reinforces the importance of the education and health component in this program.

Keywords: Chagas Disease, Triatomines, Community Participation, Vector Control

Introduction

Chagas disease is endemic in Latin America, from the north of Mexico to the south of Argentina and Chile, it is among the main four endemics being one of the biggest sanitary issues [1]. In Brazil, even controlling the occurrence of new cases, Chagas disease magnitude remains relevant with estimates varying from 1.0 to 2.4% of the population, which represents 1.9 to 4.6 million people infected by *Trypanosoma cruzi* [2].

The history of Chagas disease in São Paulo state was a model to Brazil and Latin American countries due to the successful control and elimination of *Triatoma infestans*, considered the main vector species [3, 4]. Since 1970 passive surveillance strategy, that is, with community participation, has been carried out in the state as a pilot project aiming at reducing house to house search and higher participation of population in notifying domiciled triatomines, by using a network of Triatomines Information Station (Postos de Informação de Triatomíneos) [5]. Results indicated that community participation in the triatomines detection process means continuous surveillance in contrast with vertical activities of vectors collection carried out by field teams, in which higher positive results were observed in domiciles regarding captures by the resident [6].

Concerning control, community participation to notify triatomine suspect insects has been encouraged in the state since 1983 with entomologial research in domicile as a response to every notification of triatomine forwarded by residents and increasing education professionals guiding efforts towards local communities [7].

It was only after 2004 that entomological surveillance became exclusively through community participation by sending triatomines suspect samples and has been allowing vector detection and monitoring the situation, such as finding triatomines from *Rhodnius neglectus* species in urban areas in Araçatuba and Ribeirão Preto cities, transported by birds (parrots) and colonizing palm trees, reaching apartments on the 10th floor, as well as presence and colonization of *Panstromgylus megistus* species in urban areas of different municipalities in the Metropolitan Region of São Paulo and Campinas municipality, posing risk to human population [8, 9].

The aim of this article is to assess the current stage of epidemiological surveillance for Chagas disease in São Paulo state with

emphasis on community participation and to propose adjustments on strategies in place.

Methods

This is an exploratory descriptive study in which results from activities developed in the Chagas Disease Control Program, carried out in a centralized way by the control agency of the Secretary of Health from 1990 to 2001, were analyzed and compose the computerized database. In the 90s and beginning of 2000s the entomological surveillance efforts included active search activities in locations according to infestation criteria, plus notification of triatomines registered by residents. From 2004 on, active search activities were suspended and checking notifications from community participation prevails.

Notification checking is established to occur within 60 days after the insect is captured. Trained field teams from the state agency are responsible for inspection and implementation of activities including meticulous search for vectors in the notifying domicile (intradomicile and peridomicile), addressing feeding sources. When new samples or viable eggs are found, chemical control using pyrethroid insecticides is carried out. In addition, when there is notification of *Rhodnius neglectus* species in urban areas a local team conducts entomological research in palm trees [8].

Vector control is carried out by spraying properties, using pyrethroid insecticides where triatomines were collected, whether in its domicile or peridomicile. Triatomines collected are submitted to an intestinal content checking to identify if they are trypanosomatids positive, with special reference to *Trypanosoma cruzi*. On those with positive result-stained smears are made following May-Grünwald Giemsa method for a correct diagnosis. Then, a sample of this content is collected to verify feeding habits in a battery of antisera: human, marsupial, rodent, bird, dog, and cat, through precipitation technique (up to 2016) and, after that, Elisa [10].

Serological exam through two methods (RIFI and Elisa) was run on residents where intradomicile colonies of triatomines of any species associated with *T. cruzi* infection were found, besides family epidemiological investigation in domiciles with seropositive individuals. This procedure took place until 2014. Serological positive cases were investigated in order to characterize them concerning origin and sent to follow up at health agencies in the region of residence.

Standardized sheets were used during field and laboratory activities to transcript information throughout the state. In this study, entomological research information was grouped in a single database. Using this database, it was possible to prepare thematic maps for the species. Triatomines collection registries were grouped by quadrennium from 1990 on.

Data were analyzed with support of Epi-info, 2002 program. The t test of *Student* was used to verify significance among averages in the analyses, with confidence interval of 95%.

Results

Epidemiological surveillance carried out by population resulted in 46,129 notifications of triatomines, coming from 35.5% of municipalities in the state and 27.1% were positive when checked (Table 1). When the first and last quadrennium were compared, there was decrease of 72.0% in the number of notifications as well as decrease of 20.6% in the number of municipalities with notification.

Fig 1 shows spatial distribution of triatomines notifications. Municipalities presenting at least one notification indicate the regions of São José do Rio Preto and Araçatuba, in the northwest of the state, Vale do Ribeira and Sorocaba, in the south, as well as Ribeirão Preto and municipalities in the border of Minas Gerais state as higher concentration areas. Light areas may be observed in the regions of Tatuapé, Campinas and Marília, in the central region, and Presidente Prudente, in the west. It is important to highlight São Paulo Metropolitan Region as, in the last decade, emerges with higher registries of triatomines occurrence.

Considering active search for triatomines in comparison with notification checking activity (passive search) the number of positive domiciles and peridomiciles was higher for the latter between 1990 and 2013. While the percent positive obtained at checking indicate percentages of 10.7 and 34.3 for intradomicile and peridomicile, in the active search these percentages were 1.5 and 12.2, respectively.

A total of 230,303 triatomines were collected predominating *Triatoma sordida* (74.9%) (Table 2). Between the first and last quadrennium there was decrease of 60.2% in the number of triatomines collected. In the last quadrennium *Rhodnius neglectus* species became the most collected one because of captures in palm trees located in urban areas. Higher natural infection rates were observed for *Triatoma tibiamaculata* (18.6%), however colonization was not observed, followed by *Panstrongylus megistus* (9.4%) which has colonized urban areas. *Triatoma infestans* species was found in the state in 1990 in Tapiratiba municipality, in 1994 in Sumaré municipality, and in 1999 in Paulínia municipality, all the cases with no natural infestation detected. *T. cruzi* positivity was confirmed for 2,815 samples (1.4%) among all triatomines checked. Feeding habits analyses indicated 15.4% of human blood ingestion in positive triatomines. Skunk blood (15.4%), bird (9.6%), and rodent (3.8%) were also detected.

Most results were non-reagent. In general context, anthropophilic rate observed for *P. megistus* (17.1%) was not statistically significant ($p>0.05$) in relation to *T. sordida* (14.8%). Regarding adult forms of triatomines, anthropophilic rates were higher for females in relation to males ($p<0.05$).

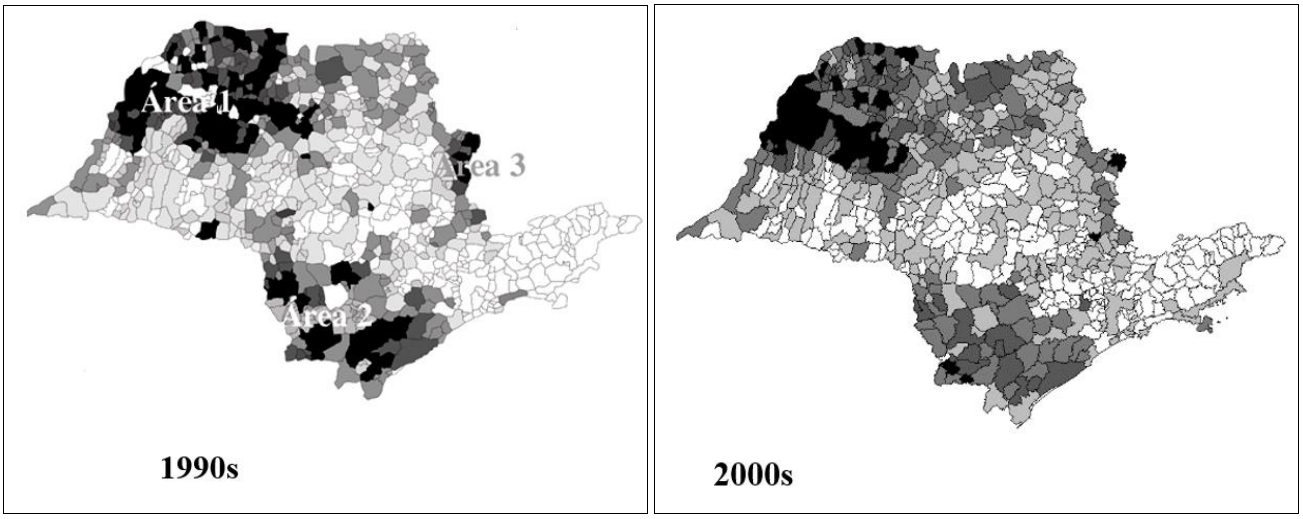
In 41,271 intradomiciles where triatomines samples were collected, nymphs were observed in 5,044 of them representing colonization rate of 12.2%, which varied from 8.4% to 16.1% over quadrennium (Table 3).

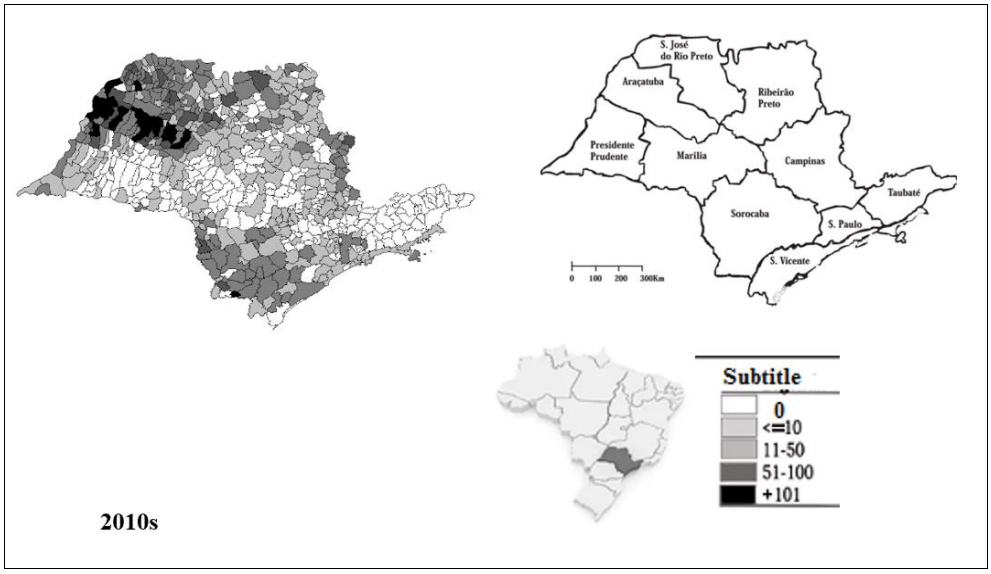
Serology applied to human residents in 1,323 domiciles was positive in 1.4% of samples (Table 4). Concerning origin, Minas Gerais, Bahia, Alagoas, Pernambuco, and Paraíba states were indicated as well as individuals born in São Paulo state whose age is compatible with former transmission. Age of people who were positive ranged from 15 to 82 years old. The number of samples collected over the period decreased.

Table 1: Notifications of triatomines attended and results of consultations in the state of São Paulo from 1990 to 2021

Year	Answered notifications	Result of attendance				Number of municipalities
		Positives		Negative		
		Nº	%	Nº	%	
1990	2868	710	24.8	2158	75.2	243
1991	2567	616	24.0	1951	76.0	215
1992	2536	728	28.7	1808	71.3	270
1993	2071	497	24.0	1574	76.0	238
Subtotal	10042	2551	25.4	7491	74.6	242
1994	2298	722	31.4	1576	68.6	261
1995	1575	783	49.7	792	50.3	228
1996	1892	642	33.9	1250	66.1	248
1997	2067	497	24.0	1570	76.0	259
Subtotal	7832	2644	33.8	5188	66.2	249
1998	1352	360	26.6	992	73.4	232
1999	1221	307	25.1	914	74.9	229
2000	1318	310	23.5	1008	76.5	234
2001	1375	383	27.9	992	72.1	237
Subtotal	5266	1360	25.8	3906	74.2	233
2002	788	221	28.0	567	72.0	152
2003	1209	311	25.7	898	74.3	240
2004	1490	492	33.0	998	67.0	231
2005	3441	923	26.8	2518	73.2	277
Subtotal	6928	1947	28.1	4981	71.9	225
2006	2250	496	22.0	1754	78.0	259
2007	1663	403	24.2	1260	75.8	232
2008	1763	441	25.0	1322	75.0	231
2009	954	201	21.1	753	78.9	220
Subtotal	6630	1541	23.2	5089	76.8	236
2010	948	240	25.3	708	74.7	270
2011	949	260	27.4	689	72.6	289
2012	888	246	27.7	642	72.3	251
2013	743	215	28.9	528	71.1	244
Subtotal	3528	961	27.2	2567	72.8	264
2014	1086	341	31.4	745	68.6	211
2015	749	140	18.7	609	81.3	193
2016	557	137	24.6	420	75.4	168
2017	797	193	24.2	604	75.8	209
Subtotal	3189	811	25.4	2378	74.6	195
2018	780	170	21.8	610	78.2	210
2019	735	153	20.8	582	79.2	210
2020	629	179	28.5	450	71.5	182
2021	570	174	30.5	396	69.5	165
Subtotal	2714	676	24.9	2038	75.1	192
Grand total	46129	12491	27.1	33638	72.9	229

Source: Chagas Entomological Surveillance State System





Source: Chagas State Entomological Surveillance System

Fig 1: Distribution of triatomine notifications received by municipality. State of São Paulo, the 1990s, 2000s and 2010s

Table 2: Triatomines collected, examined and positive according to year and species in the state of São Paulo from 1990 to 2021

	Triatoma infestans				*Triatoma sordida*				*Panstrongylus megistus*				*Rhodnius neglectus*				*Triatoma tibiamaculata*				Others				Total			
Year	Col	Exam	Posit	%Posit	Col	Exam	Posit	%Posit	Col	Exam	Posit	%Posit	Col	Exam	Posit	%Posit	Col	Exam	Posit	%Posit	Col	Exam	Posit	%Posit	Col	Exam	Posit	%Posit
1990	1	1	0	0.0	7013	6133	19	0.3	1643	1572	137	8.7	292	167	0	0.0	59	41	8	19.5	28	26	1	3.8	9036	7940	165	2.1
1991	0	0	0	0.0	6169	5544	19	0.3	1519	1351	51	3.8	341	245	1	0.4	75	72	10	13.9	25	18	0	0.0	8129	7230	81	1.1
1992	0	0	0	0.0	8742	7654	19	0.2	2253	1982	43	2.2	327	247	0	0.0	87	77	8	10.4	30	25	0	0.0	11439	9985	70	0.7
1993	0	0	0	0.0	8280	7490	64	0.9	1428	1129	133	11.8	279	211	1	0.5	63	57	14	24.6	18	18	0	0.0	10068	8905	212	2.4
Subtotal	1	1	0	0.0	30204	26821	121	0.5	6843	6034	364	6.0	1239	870	2	0.2	284	247	40	16.2	101	87	1	1.1	38672	34060	528	1.6
1994	1	1	0	0.0	9810	8476	47	0.6	1514	1453	238	16.4	296	210	2	1.0	64	54	5	9.3	16	13	0	0.0	11701	10207	292	2.9
1995	0	0	0	0.0	6874	6236	39	0.6	503	403	32	7.9	314	174	1	0.6	48	41	11	26.8	19	17	1	5.9	7758	6871	84	1.2
1996	0	0	0	0.0	8712	7971	34	0.4	659	545	47	8.6	400	285	0	0.0	38	32	10	31.3	22	9	0	0.0	9831	8842	91	1.0
1997	0	0	0	0.0	11569	10634	106	1.0	845	803	21	2.6	420	289	1	0.3	66	56	14	25.0	37	35	0	0.0	12937	11817	142	1.2
Subtotal	1	1	0	0.0	36965	33317	226	0.7	3521	3204	338	10.5	1430	958	4	0.4	216	183	40	21.9	94	74	1	1.4	42227	37737	609	1.6
1998	2	2	0	0.0	6358	5174	22	0.4	512	416	7	1.7	318	202	0	0.0	61	52	7	13.5	3	1	0	0.0	7254	5847	36	0.6
1999	106	35	0	0.0	5845	4229	32	0.8	635	510	9	1.8	370	250	1	0.4	59	50	21	42.0	9	7	1	14.3	7024	5081	64	1.3
2000	0	0	0	0.0	8172	7265	34	0.5	122	93	6	6.5	335	207	0	0.0	93	72	0	0.0	32	30	0	0.0	8754	7667	40	0.5
2001	0	0	0	0.0	7332	6469	18	0.3	371	326	34	10.4	336	228	2	0.9	105	89	19	21.3	34	34	0	0.0	8178	7146	73	1.0
Subtotal	108	37	0	0.0	27707	23137	106	0.5	1640	1345	56	4.2	1359	887	3	0.3	318	263	47	17.9	78	72	1	1.4	32210	25741	213	0.8
2002	0	0	0	0.0	7401	6760	12	0.2	538	456	61	13.4	244	194	0	0.0	41	40	2	5.0	16	16	2	12.5	8240	7466	77	1.0
2003	0	0	0	0.0	5227	4709	16	0.3	450	430	25	5.8	260	185	5	2.7	57	50	2	4.0	14	13	0	0.0	6008	5387	48	0.9
2004	0	0	0	0.0	7494	7121	14	0.2	807	724	49	6.8	360	328	2	0.6	106	92	28	30.4	37	28	0	0.0	8804	8293	93	1.1
2005	0	0	0	0.0	14564	13993	23	0.2	839	735	52	7.1	866	665	7	1.1	246	220	49	22.3	59	46	0	0.0	16574	15659	131	0.8
Subtotal	0	0	0	0.0	34686	32583	65	0.2	2634	2345	187	8.0	1730	1372	14	1.0	450	402	81	20.1	126	103	2	1.9	39626	36805	349	0.9
2006	0	0	0	0.0	9031	8547	22	0.3	715	598	86	14.4	470	381	1	0.3	167	131	25	19.1	45	41	0	0.0	10428	9698	134	1.4
2007	0	0	0	0.0	6267	5951	11	0.2	476	442	47	10.6	492	382	1	0.3	130	114	20	17.5	26	24	0	0.0	7391	6913	79	1.1
2008	0	0	0	0.0	6530	6254	44	0.7	385	336	30	8.9	640	514	0	0.0	101	79	10	12.7	33	27	0	0.0	7689	7210	84	1.2
2009	0	0	0	0.0	5720	5395	26	0.5	503	454	34	7.5	151	131	0	0.0	75	60	8	13.3	29	28	0	0.0	6478	6068	68	1.1
Subtotal	0	0	0	0.0	27548	26147	103	0.4	2079	1830	197	10.8	1753	1408	2	0.1	473	384	63	16.4	133	120	0	0.0	31986	29886	365	1.2
2010	0	0	0	0.0	2904	2815	2	0.1	672	588	144	24.5	240	224	1	0.4	42	35	5	14.3	19	18	0	0.0	3877	3680	152	4.1
2011	0	0	0	0.0	3731	3563	8	0.2	1496	1004	274	27.3	233	206	0	0.0	24	15	0	0.0	9	9	0	0.0	5493	4797	282	5.9
2012	0	0	0	0.0	5674	5416	53	1.0	285	223	10	4.5	295	272	0	0.0	9	5	0	0.0	1	1	0	0.0	6264	5917	63	1.1
2013	0	0	0	0.0	4228	3990	34	0.9	186	138	3	2.2	174	170	0	0.0	28	26	7	26.9	13	11	0	0.0	4629	4335	44	1.0
Subtotal	0	0	0	0.0	16537	15784	97	0.6	2639	1953	431	22.1	942	872	1	0.1	103	81	12	14.8	42	39	0	0.0	20263	18729	541	2.9
2014	0	0	0	0.0	3603	3246	7	0.2	197	180	2	1.1	188	122	0	0.0	20	20	3	15.0	6	6	1	16.7	4014	3574	13	0.4
2015	0	0	0	0.0	2175	1967	12	0.6	216	182	7	3.8	109	88	0	0.0	27	26	4	15.4	10	8	0	0.0	2537	2271	23	1.0
2016	0	0	0	0.0	1717	1566	9	0.6	140	128	3	2.3	91	69	1	1.4	22	21	5	23.8	7	5	0	0.0	1977	1789	18	1.0
2017	0	0	0	0.0	2037	1856	4	0.2	241	213	23	10.8	132	108	0	0.0	14	14	4	28.6	13	12	0	0.0	2437	2203	31	1.4
Subtotal	0	0	0	0.0	9532	8635	32	0.4	794	703	35	5.0	520	387	1	0.3	83	81	16	19.8	36	31	1	3.2	10965	9837	85	0.9
2018	0	0	0	0.0	1903	1437	1	0.1	189	152	21	13.8	1029	984	1	0.1	26	26	6	23.1	7	6	0	0.0	3154	2605	29	1.1
2019	0	0	0	0.0	1610	1409	3	0.2	366	211	23	10.9	94	63	0	0.0	17	17	6	35.3	8	6	0	0.0	2095	1706	32	1.9
2020	0	0	0	0.0	2621	2112	3	0.1	274	130	23	15.3	2909	526	2	0.4	9	9	2	22.2	10	9	0	0.0	5823	2806	30	1.1
2021	0	0	0	0.0	1467	1198	0	0.0	168	135	29	21.5	2616	665	0	0.0	23	21	5	23.8	8	7	0	0.0	4282	2026	34	1.7
Subtotal	0	0	0	0.0	7601	6156	7	0.1	997	648	96	14.8	6648	2238	3	0.1	75	73	19	26.0	33	28	0	0.0	15354	9143	125	1.4
Grand total	110	39	0	0.0	190780	172580	757	0.4	21147	18062	1704	9.4	15621	8992	30	0.3	2002	1714	318	18.6	643	554	6	1.1	231303	201938	2815	1.4

Source: Chagas State Entomological Surveillance System
(Col = collected; Exam = examined; Posit = positives; %Posit = %positives)

Table 3: Indoor colonization by triatomines in the state of São Paulo from 1990 to 2021

Year	Intradomicile		
	Positive (N)	With nymph(N)	%
1990	2483	187	7.5
1991	2292	196	8.6
1992	2220	170	7.7
1993	1875	193	10.3
Subtotal	8870	746	8.4
1994	2255	343	15.2
1995	1198	215	17.9
1996	1655	135	8.2
1997	1833	142	7.7
Subtotal	6941	835	12.0
1998	1189	91	7.7
1999	1032	84	8.1
2000	208	27	13.0
2001	183	24	13.1
Subtotal	2612	226	8.7
2002	976	79	8.1
2003	1170	175	15.0
2004	1994	358	18.0
2005	3599	548	15.2

Subtotal	7739	1160	15.0
2006	2135	330	15.5
2007	1893	271	14.3
2008	1832	235	12.8
2009	955	144	15.1
Subtotal	6815	980	14.4
2010	1122	193	17.2
2011	1017	151	14.8
2012	868	155	17.9
2013	720	102	14.2
Subtotal	3727	601	16.1
2014	840	106	12.6
2015	612	59	9.6
2016	481	65	13.5
2017	633	67	10.6
Subtotal	2566	297	11.6
2018	613	67	10.9
2019	432	38	8.8
2020	586	60	10.2
2021	370	34	9.2
Subtotal	2001	199	9.9
Grand total	41271	5044	12.2

Source: Chagas State Entomological Surveillance System

Table 4: Results of serology for the diagnosis of Chagas disease, applied to residents of households with the presence of triatomines infected with *Trypanosoma cruzi*. State of São Paulo, 1990 to 2013

Year	Household units examined	Examined samples	Reagents	
			Nº	%
1990	193	777	10	1.3
1991	223	760	12	1.6
1992	167	813	5	0.6
1993	188	1036	13	1.3
Subtotal	771	3386	40	1.2
1994	113	519	11	2.1
1995	52	240	4	1.7
1996	36	138	2	1.4
1997	38	145	3	2.1
Subtotal	239	1042	20	1.9
1998	23	71	0	0.0
1999	30	151	0	0.0
2000	65	175	7	4.0
2001	47	165	2	1.2
Subtotal	165	562	9	1.6
2002	57	167	3	1.8
2003	36	119	3	2.5
2004	25	97	1	1.0
2005	10	15	0	0.0
Subtotal	128	398	7	1.8
2006	4	10	1	10.0
2007	2	13	1	7.7
2008	2	9	0	0.0
2009	3	14	0	0.0
Subtotal	11	46	2	4.3
2010	3	10	0	0.0
2011	2	12	0	0.0
2012	2	7	0	0.0
2013	2	12	0	0.0
Subtotal	9	41	0	0.0
Grand total	1323	5475	78	1.4

Source: Chagas State Entomological Surveillance System

Discussion

Triatomines notification through community participation came from all areas of the state, in higher or lower degree, and silent areas in the 90s have gone through changes in the following decades. From 2004 on, notifications by residents lead to any action related to triatomines control in the state. Therefore, it is important that if a resident suspect of an insect they know how to collect and forward it to the responsible agencies [4]. Community participation in triatomines detection means continuous surveillance and previous screening of domiciles to be searched, addressing the probability of infested domiciles, which has been evidenced in previous study and in this study [6]. However, it was observed decrease in the number of notifications

forwarded by residents, which may be for two reasons: decrease in the number of samples that invaded domiciles because of infestation decrease or reduced encouragement for population to notify, yet percentage variation in positive checking's were not observed.

Community participation is a dynamic and instrumental process that given population, previously motivated, employs for its own and collective benefit. Searching alternative methodologies that allow awareness, involvement in the process and increasing notification must be pursued. When social innovation criteria are included in the controlling initiative empowering populations there is higher sustainability in actions [11].

As observed for community participation, there was important reduction in the number of triatomines samples collected over the quadrennium and increase in the dispersion area, however with minor variations in colonization rates over the period. Intradomicile colonization is a basic factor for Chagas disease transmission to human and finding nymphs may be a sign for fertile females invasion which are found by the resident and notified after eggs laying, thus hatching and nymphs remain in the residence. These nymphs are found and collected by the field teams when checking notifications.

Although *T. sordida* is the most collected species in the state, *R. neglectus* has been the most abundant one over the last years because of high densities found in urban area, however there is no observation of natural infection [12]. *T. sordida* species has been mainly found in rural area, linked with birds, resulting in low natural infection rates and located basically in the peridomicile of residences, which incurs low risk to humans.

Nevertheless, it must be considered that using the antisera battery for *T. cruzi* positive triatomines indicated wide feeding mobility, that is, when insects invade domiciles, they already carry with them natural infection from outside of the domicile which infection sources are, most probably, rodent and marsupial, indicating variety of feeding sources.

It is important to highlight that *T. infestans* findings in São Paulo state were related to passive transportation and readily notified by residents in the domiciles. At this point, activities, actions and strategies developed in the educational component lead by the municipal sphere in the state are essential to keep population aware and monitor the presence of vectors in domiciles. Besides, considering the new setting of finding and colonization of triatomines in urban area, community participation and involvement in all stages of the process becomes a strategic component for Chagas disease surveillance [13].

However, *P. megistus* has been given more attention in the state due to constant invasion in domiciles in urban area, followed by *T. cruzi* infection, and because they can still colonize domicile environment. In urban area, this species has been using ecological corridors formed mainly by urban parks and it is linked with skunks (*Didelphis* sp.), resulting in high natural infection rates [9].

In addition, population in urban areas does not identify Chagas disease as a health issue, relating the disease to rural areas and poor housing conditions, which does not reflect reality in urban centers where high standard residential condominiums have been affected by the presence of vectors and *T. cruzi* circulation. In Mambaí and Burtinópolis, Goiás state, it was observed that young population is unaware about the vector and its connection with Chagas disease, and they do not know how to proceed if they find a suspect insect [14]. Added to that, in Peru it has been observed that Chagas disease parasites, vectors, and host are directly related to the urbanization dynamic, that is, vectors populations expand as city grows, which may indicate to the development of educational initiatives in the areas [15].

In this context, Chagas disease represents a challenge that adds a different dimension to the issue due to specific characteristics of lifestyle in urban conglomerates, which will demand adjustments to the vector control programs from rural to urban area [16]. Adequacies in strategies in place must be considered by establishing a network of suspect insects notification for vectors control areas in urban area, implementing health education efforts about forwarding insects flows as well as actions created to monitor vectors in domiciles. Some authors indicate that implementing continuous strategies and wide community participation may change knowledge level on the disease and incur higher involvement in actions undertaken [17, 18, 19].

Results of this study support the non-occurrence of vectorial transmission of Chagas disease in São Paulo state. Investigation on individuals with reactive serology indicated infection acquisition prior to state control or in other states of the country, where Chagas disease is or has already been endemic. Up to 2013, when serology was run in residents related to triatomines collected in intradomicile environment and *T. cruzi* positive, it was not confirmed that seroreactive people were linked with contamination by wild species of triatomines. History of individuals with positive serological results are consistent with imported or acquired transmission in the past in the state when transmission was active [20].

It is noteworthy that this study presents methodological limitations usual to research based on secondary data, mainly regarding underreporting of suspect insects, but it is justified as an operative valuation of Chagas disease surveillance and trend analyses of triatomines species domiciliation in São Paulo state.

Triatomines colonization in new environments require the involvement of new players to face the situation, also considering that these new differentiated strategies of action and wider coverage and impact must be implemented and for that matter creating distance training modules that include aspects related to the vector, parasites and environmental management control, entomological research, and chemical control. Implementing integrated strategies of health and education on Chagas disease, with the objective of training and clarification for municipal agents may contribute to strengthen health surveillance in São Paulo state, which will qualify and widen its operating capacity.

In addition, adopting actions that may impact vectors surveillance and monitoring as well as *T. cruzi* circulation, such as: entomological researches driven to knowledge of vectors in the areas; ecosystem surveillance where there may be cycles of diseases that involve vectors and wildlife reservoirs associated with epidemiological monitoring that may result in locating such reservoirs before the disease transmission cycle begins; implementing a continuous action structure in order to monitor risk factors by examining animals found (wild, domiciled, domesticated, or synanthropic) to identify etiologic agents through lab exams, that is, implementing animal surveillance that may add to detect animal species carrying several infections, being the one caused by *T. cruzi* among them, this would reduce the

incidence of this and other anthropozoonoses and thus promote effective control of diseases transmitted by vector in São Paulo state.

Conclusion

Entomological surveillance of triatomines with community participation has proven to be effective. The colonization of triatomines in large urban centers reinforces the importance of the educational component in this program and in new strategies such as monitoring the circulation of *Trypanosoma cruzi*, with the institution of animal surveillance.

Ethics Approval and Consent Participate

The study was submitted and approved by the Research Ethical Committee from São Paulo Municipal Health Office (Report N. 5.361.875) and analysis was conducted based on secondary data with disclosure of grouped data only.

Data Availability

All data are available in the article and futher details can be requested directly from the corresponding author.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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