Original article

Entomological and epidemiological aspects of dengue epidemics in Fortaleza, Ceará, Brazil, 2001-2012*

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Abstract

Objective: to characterize the entomological and epidemiological aspects of dengue epidemics occurred in Fortaleza, Ceará, Brazil, from 2001 to 2012. **Methods**: descriptive study with data from the Information System for Notifiable Diseases (Sinan), Information System of Hospitalizations due to Yellow Fever and Dengue (2001-2009), National Program for Dengue Control (2010-2012), and Rapid Survey of *Aedes aegypti* Infestation Index, referring to the years in which the incidence of dengue was above 75%. **Results**: from 2001 to 2012, 194,446 cases of suspected dengue were notified; the epidemic years were 2001, 2006, 2008, 2011 and 2012; there was a progressive increase in the incidence of the disease (587.0/100 thousand inhabitants in 2001 and 1,561.1/100 inhabitants in 2012); there was co-circulation of up to three serotypes and high vector infestation, especially in water tanks. **Conclusion**: after a long period of virus circulation in Fortaleza, dengue remains as an important health issue, with severe cases and high fatality rate.

Keywords: Dengue; Epidemiological Surveillance; *Aedes*; Epidemiology, Descriptive.

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Introduction

Dengue is still a major public health issue in Brazil, even after the recent introduction and dissemination of the Zika and chikungunya viruses.[1,2] The disease poses a serious epidemic threat, striking Brazil as a whole, especially the Northeast region.[3-5]

The repercussion of these epidemics is evident in the assistance offered to patients and in the epidemiological surveillance, often exposing their weaknesses and causing impacts of socioeconomic, political, and psychological natures.[6] Moreover, dengue epidemics have a higher cost due to hospitalization, medical assistance, and vector prevention and control measures, resulting in a significant budgetary burden to health care services. From 2000 to 2007, Brazil was responsible for around 41% of the expenditure on dengue in the Americas.[7,8]

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Despite the vector control actions adopted by health care services, the state of Ceará, in the Northeast region, has recorded major epidemics since the 1990s.[9-11] The municipality of Fortaleza, capital of Ceará, gathers a large portion of cases in the state, recording cases of dengue fever since 1986, major epidemics, and high levels of fatality.[10,11]

In order to avoid and reduce the impact of such epidemics, it is important to understand their specific characteristics in each region. This way, for a better overview of the mechanisms involved in dengue epidemics in large urban centers, the aim of this study was to characterize entomological and epidemiological aspects of dengue epidemics that occurred in Fortaleza, Ceará, Brazil, in the period from 2001 to 2012.

Methods

All the years when dengue incidence was above 75% between 2001 and 2012 were analyzed in this descriptive study.

In 2012, Fortaleza was the 5th most populous state capital in Brazil, with approximately 2,591,114 inhabitants residing in 119 neighborhoods and distributed into six administrative regions called Regional District Offices (SER).[12]

The study includes all confirmed cases of the disease, between January 2001 and December 2012, in individuals residing in Fortaleza. Cases were considered confirmed by laboratory and clinical-epidemiological criteria. For that, we used the definition of case adopted by the Brazilian Ministry of Health.[13] We considered cases of dengue those in which an individual a) resides in areas with incidence of the disease, or b) has been to areas with occurrence of transmission (or of *Aedes aegypti*) in the past 14 days, and who the presence fever from two to seven days, and two or more of the following symptoms: nausea, vomiting, rash, myalgia, arthralgia, headache, retro-orbital pain, petechiae, positive result in the tourniquet test, leukopenia.

The epidemiological data were obtained from the Information System for Notifiable Diseases (Sinan) in its three versions: Sinan-Windows (2000-2006), Sinan-Net (2007-2010), and Sinan-Online (2011-2012).[14] For the calculation of dengue incidence rate, we considered the number of cases as the numerator, while the denominator was the population estimated by the Brazilian Institute of Geography and Statistics (IBGE) multiplied by 100,000. The information was available in the Department of the Brazilian National Health System (Datasus). The incidence rate was also calculated in relation to sex and age group. The number of hospitalizations was obtained from the National Hospital Information System (SIH/SUS).

The analyzed variables had the following characteristics: sociodemographic and epidemiological; laboratory; hospitalizations; and entomological.

The sociodemographic variables corresponded to age group (in years: <9; 10 to 19; 20 to 49; 50 to 79; ≥80) and sex (male; female).

The epidemiological characteristics considered for the study were:

- final classification used by the Ministry of Health until 2013 (classical dengue fever, dengue with complications, dengue hemorrhagic fever [DHF], dismissed cases, cases under investigation, unknown);
- confirmation criteria (laboratory, clinic-epidemiological, under investigation, dismissed);

- evolution (cure, death caused by dengue, death by other causes, unknown);
- hospitalization period (in days: <1; 1 to 5; 6 to 14; 15 to 21; 22 to 28; ≥29); and
- month and year when the symptoms started

The entomological data were extracted from spreadsheets of building infestation rate (BIR), collected by the Municipal Health Department of Fortaleza, from the Yellow Fever and Dengue Information System (SisFAD) until 2009; from the National Program for Dengue Control System (SisPNCD) since 2010; and from the Rapid Survey of *Aedes aegypti* Infestation Index (LIRAa).[15] According to the Ministry of Health, deposits of water infected by the *Aedes aegypti* mosquito must be categorized into five major groups: A, B, C, D, and E.[15] Containers used to store water are in group A. Given its importance, group A was further divided into categories A1 (water tanks) and A2 (containers to store water at ground level). Deposits considered mobile, such as pots, bottles, fridge defrosting containers, drinking fountains in general, small ornamental fountains, etc., are in group B. Deposits considered fixed, such as tanks in auto repair shops, rain gutters, flat roofs, toilets in disuse, untreated swimming pools, pots left in cemeteries, etc., are in group C. Deposits subject to mechanical removal are in group D; once again, given the relevance of such deposits as potential breeding sites, the group was further divided into D1 (tires) and D2 (garbage). Finally, natural containers such as plant axils, bromeliad flowers, holes in trees, rock formations, etc., are in group E.[15] The percentage of deposits infected by the *Aedes aegypti* mosquito is represented according to data from each Regional District Office.

Dengue fatality rate was calculated dividing the number of deaths caused by dengue hemorrhagic fever (DHF) by the number of confirmed cases of DHF, multiplied by 100.

The databases were analyzed after eliminating duplicate cases for each year of epidemics. Afterwards, the information from the three versions of Sinan were gathered in a single database for analysis. In the calculation of descriptive statistics, we used the software EpilInfo® v.6.0 and Tabwin 32.

For the conduction of the study, we followed the ethical principles as recommended by the Resolution No. 466 of the National Health Council (CNS), dated December 12th, 2012.[16] Due to the secondary nature of the data collected, where no cases were identified, the study was authorized by the Municipal Health Department of Fortaleza and thus approved by the Ethics Research Committee of the University of Ceará (CEP/UFC) on November 1st, 2013: Federal Protocol No. 20301313.6.0000.5054.

Results

In the period from 2001 to 2012, 194,446 suspected cases of dengue were recorded. The years considered as epidemic, with a higher incidence of confirmed cases, were 2001 (587.0/100 thousand inhabitants), 2006 (637.5/100 thousand inhabitants), 2008 (1,396.6/100 thousand inhabitants), 2011 (1.387,3/100 thousand inhabitants) and 2012 (1,561.1/100 thousand inhabitants) (Figure 1). These epidemics were marked by the spreading of different serotypes and simultaneous co-circulation of up to three serotypes in a single year, as observed in 2002 and 2003. In 2001, there was a subtle prevalence of serotype DENV-2 (53.0%) associated with the co-circulation of DENV-1 (47.0%). In 2006, the prevalence was of serotype DENV-3 (90.0%); in 2008, of DENV-2 (65.0%); in 2001, of DENV-1 (97.4%); while, in 2012, the serotype DENV-4 was introduced (98.0%). In all of the aforementioned years, there was co-circulation of at least two different viral serotypes (Figure 1).

The months of April, May, and June concentrated over 70% of confirmed cases, especially May 2001 (30.1%) and May 2008 (33.8%). There were confirmed cases throughout every epidemic year. The month of May 2012 concentrated over 52% of the confirmed cases in that year (Table 1).

After the epidemic in 2008, there was a subtle increase in the percentage of inconclusive cases. The epidemic with most recorded deaths was occurred in 2006, with a total of 36 confirmed deaths (Table 1).

There was a prevalence of cases in women, ranging from 54.4% (2011) to 60.4% (2001). It was recorded a higher number of cases in the age group of individuals between 20 and 49 in all the epidemic years, proportionally. There was a significant increase in infection within those under the age of 9 (23.7%) during the 2008 epidemic (Table 2). The average age of cases was 27.7 years old (0 to 95). Throughout the first three epidemics, there was a decrease in the age of infection, and a subtle increase starting from 2011. In the epidemic years between 2001-2012, the median age decreased significantly.

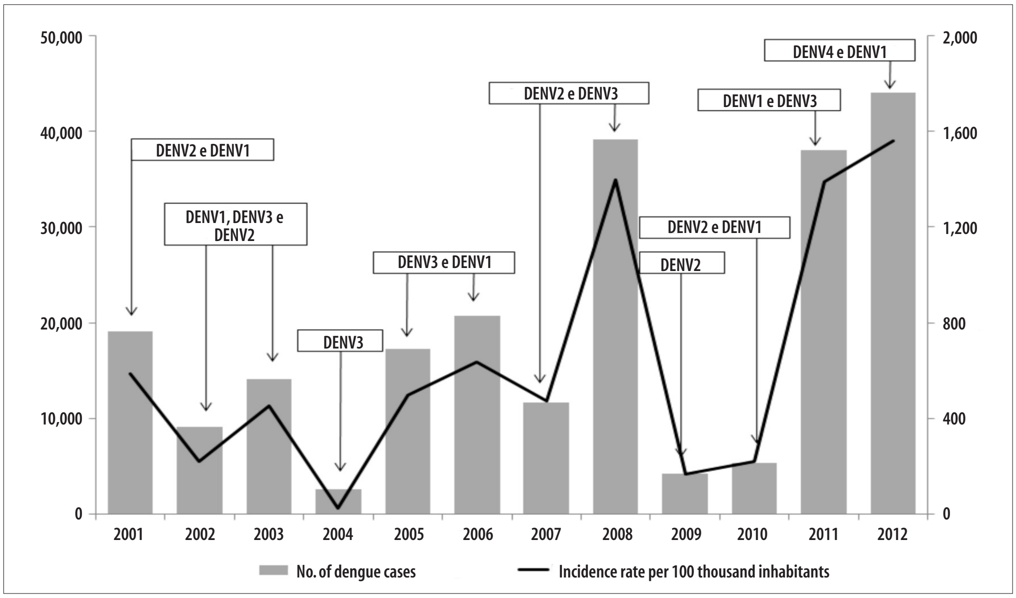

Figure 1 – Number of cases, incidence rate, and circulating serotypes of dengue, Fortaleza, Ceará, 2001-2012

Among those admitted to the hospital, the average time of hospitalization was 6.4 days (1 to 30). In the epidemics of 2001, 2006, 2008, and 2011, the majority of individuals was hospitalized from 1 to 5 days. In 2012, most hospitalizations (57.4%) were recommended for a period from 6 to 14 days, suggesting higher severity (Table 2).

In general, women had higher prevalence among severe cases, especially in 2001 (62.1%); the exception was 2011, with 48.5% women comprising such cases (Table 2). The higher frequency of severe cases of the disease was found among the age groups 20 to 49 (49.8%) and 10 to 19 (19.5%). In 2008, severe cases in children below 9 represented 19.6% of cases. Average fatality for DHF in the period was of 13.7%, ranging from 17.2% in 2001 to 3.4% in 2008 (Table 2).

The incidence rate of the disease was always higher among women, varying between 662.0 cases/100 thousand inhabitants in 2006 and 1,675.5 cases/100 thousand inhabitants in 2012. It is worth mentioning the substantial increase in incidence among those below 9 years old, a rate that reached 2,331.3 cases/100 thousand inhabitants in the 2008 epidemic (Table 3).

The number of household visit cycles and the simultaneous rapid survey of *Aedes* infestation index, conducted by health agents, ranged from three (2008) to six household visit cycles (2006). The vector infestation rates fluctuated between 0.5% during the third cycle conducted in 2008 (between October 13th and October 18th) and 9.2% during the second cycle of 2001 (conducted between May 3rd and August 24th). Four cycles presented infestation rates below 1%. The highest infestation rate was recorded in 2001, reaching 9.2% (Figure 2).

When analyzed separately by Regional District Offices (SER), the data show building infestation rates ranging from 0.2% to 14.0% in SERs II and IV, respectively, during the household visit cycles in the years of epidemics studied. SER III had the highest infestation rates, followed by SERs V, I, II, IV, and VI. In 17 cycles during the epidemic years, the building infestation, regardless of the SER, was above 1%.

The containers used to store water for human consumption represented over 50% of all deposits infested by the *Aedes aegypti* mosquito, in all epidemic years. We observed an increase in the proportion of infested plant vases and pots, from 3.4% in 2001 to 21% in 2012 (data not presented in the table). The containers used to store water (type A2) had the highest infestation rates among the deposits of water that presented larvae in SERs I, III, V, and VI. In SERs II and IV, the substantial rates were in drains and toilets (type C) (Table 4).

Table 1 – Distribution of notified dengue cases according to month of notification, classification and evolution, by epidemic year, Fortaleza, Ceará, 2001, 2006, 2008, 2011 and 2012

Variables	2001		2006		2008		2011		2012	
	n	%	n	%	n	%	n	%	n	%
Month										
January	184	1.4	152	1.0	779	2.3	1,265	3.7	573	1.5
February	275	2.2	180	1.2	1,436	4.2	2,389	7.0	965	2.5
March	948	7.4	287	1.9	2,727	7.9	6,926	20.2	2,793	7.2
April	1,772	13.8	695	4.5	11,009	31.9	11,447	33.3	6,855	17.6
May	3,851	30.1	3,272	21.2	11,667	33.8	6,715	19.5	20,564	52.6
June	2,800	21.8	4,042	26.2	4,639	13.4	2,373	6.9	5,137	13.2
July	1,890	14.7	2,984	19.4	832	2.4	923	2.7	1,054	2.7
August	610	4.8	2,004	13.0	394	1.1	625	1.8	434	1.1
September	190	1.5	797	5.2	216	0.6	445	1.3	203	0.5
October	170	1.3	434	2.8	387	1.1	417	1.2	203	0.5
November	77	0.6	374	2.4	247	0.7	372	1.1	126	0.3
December	51	0.4	187	1.2	214	0.6	455	1.3	115	0.3
Classification										
Classical dengue	12,760	67.4	15,169	73.7	33,956	86.8	34,016	89.5	38,876	88.4
Dengue with complications	–	–	118	0.6	327	0.8	234	0.6	93	0.2
Dengue hemorrhagic fever (DHF) / Dengue shock syndrome	58	0.3	121	0.6	264	0.7	102	0.3	53	0.1
Case dismissed	6,115	32.3	5,167	25.1	4,453	11.4	3,411	9.0	4,574	10.4
Inconclusive	–	–	–	–	119	0.3	222	0.6	387	0.9
Evolution										
Unknown / unclassified	120	–	246	–	5,723	0.5	3,132	0.6	2,874	2.1
Cure	18,923	99.9	20,461	99.8	33,420	99.4	34,827	99.3	41,081	97.8
Death	10	0.1	36	0.2	20	0.1	26	0.1	23	0.1
Total	19,053	100.0	20,743	100.0	39,163	100.0	37,985	100.0	43,978	100.0

Discussion

In a 12-year period (2001-2012), Fortaleza recorded five dengue epidemics. We observed a progressive increase in the incidence of the disease, which would reach its peak in 2012, the highest in the historical series of dengue in the municipality, with simultaneous circulation of more than one serotype, increase in the average hospitalization time, and high fatality rate.

A study conducted in the city of Manaus, between years 2000 and 2012, identified 2011 as the worst epidemic year in that area.[17] In the city of Natal, 2008 was the year that presented the highest incidence of the disease and – as in the present study – circulation of the serotype DENV-2.[18] Epidemic years, even within the same geographic region as the Northeast, fluctuate significantly. That is due to the moment dengue was introduced into the region, the diversity of circulating serotypes, the differences in susceptibility to the various serotypes, the simultaneous presence of such serotypes, and the installed capacity of local epidemiological surveillances and of vector control activities developed there.

Age groups in cases of dengue suffered an important shift, striking the population under 10 in 2008, presumably when children were more susceptible due to the reintroduction of DENV-2.[19]

Although we observed a subtle predominance of cases affecting women, this difference did not seem

Table 2 – Hospitalization time, number and percentage of confirmed cases of dengue, dengue with complications, dengue hemorrhagic fever (DHF), and dengue shock syndrome according to sex and age group, and fatality, Fortaleza, Ceará, 2001, 2006, 2088, 2011 and 2012

Variables	2001		2006		2008		2011		2012	
	n	%	n	%	n	%	n	%	n	%
Hospitalization Time (in days)										
<1	2	0.7	3	0.3	22	0.7	9	0.4	4	0.2
1-5	222	81.0	690	74.6	2,561	78.0	1,781	80.2	1,174	42.0
6-14	49	17.9	218	23.5	672	20.4	419	18.9	1,604	57.4
15-21	–	–	7	0.8	15	0.5	7	0.3	9	0.3
22-28	–	–	2	0.2	7	0.2	3	0.1	–	–
≥29	1	0.4	6	0.6	6	0.2	3	0.1	2	0.1
Confirmed cases of dengue										
Age group (in years)										
≤9	1,623	9.2	2,808	15.0	9,281	23.7	6,387	16.8	4,536	10.3
10-19	2,929	16.7	4,395	23.4	8,561	21.8	8,546	22.5	9,050	20.6
20-49	10,366	59.0	9,387	50.0	17,044	43.5	18,530	48.7	24,241	55.0
50-79	2,572	14.6	2,047	10.9	4,024	10.3	4,241	11.2	5,918	13.5
≥80	93	0.5	123	0.7	257	0.7	303	0.8	251	0.6
Sex										
Men	7,546	39.6	9,329	45.0	17,219	44.0	17,321	45.6	18,896	42.9
Women	11,505	60.4	11,409	55.0	21,947	56.0	20,668	54.4	25,106	57.1
Confirmed cases of dengue with complications, hemorrhagic fever, and dengue shock syndrome										
Age group (in years)										
≤9	4	6.9	22	9.4	112	19.6	34	10.1	9	6.2
10-19	9	15.5	50	21.6	119	20.8	61	18.2	23	15.8
20-49	26	44.8	138	59.2	256	44.8	166	49.4	84	57.5
50-79	19	32.8	22	9.4	79	13.8	68	20.2	25	17.1
≥80	–	–	1	0.4	6	1.0	7	2.1	5	3.4
Sex										
Unknown / unclassified	–	–	–	–	–	–	1	0.3	–	–
Men	22	37.9	105	43.9	270	45.7	172	51.2	62	42.5
Women	36	62.1	134	56.1	321	54.3	163	48.5	84	57.5
Deaths (fatality)	5	17.2	12	15.1	19	3.4	26	7.7	23	15.7

relevant, considering the epidemic years studied, which corroborates epidemics documented between 2000 and 2012 in Manaus, Natal, and São Luís.[17,18,20] However, epidemiological surveys on dengue conducted in Brazil do not suggest higher risk due to sex.[21,22,23] This finding highlights a probable bias in the recording of notified cases as these are, for the most part, cases of household transmission, and likely due to the fact that women tend to make use of health care services and seek medical attention more often than men.

The higher incidence of the disease in young adults, as found in the present study, supports the findings in researches conducted in the cities of Manaus, Natal, and São Luís.[17,18,20] In São Luis, like in Fortaleza, there was a higher number of severe forms of the disease in populations previously exposed to serotypes 1, 2, and 3.[20]

A greater severity of cases was detected in 2008, possibly due to the higher of occurrence in children 9 years old and due to the fact that DENV-2 was the main serotype in circulation that year, leading to a large number of hospitalizations.[19] In the epidemic of 2008, the number of deaths was not higher probably due to the considerable effort put into health care. In the years of epidemic, health professionals may be more aware and also the health network while dealing with the infection that, despite a larger demand, would offer early care to the severe cases and thus reduce the fatality of the disease. Moreover, the identification of a higher number of deaths is directly related to the existence of a service of death verification (SVO) established and at work alongside epidemiological surveillance and the Public Health Central Laboratory (LACEN).[24] Such collaborative local work strengthens the ability of health care services to detect questionable deaths unnoticed by assistance throughout clinical evolution.

With regard to entomological indicators, the percentage of water tanks infested by *Ae. aegypti* was three times lower; the percentage of infested tires was nine times lower, considering the epidemics between 2001 and 2012. However, there was a significant increase in proportional infestation of plant pots and vases, according to studies conducted in Manaus during 2000 - 2012, and in the Northeast region, in 2016.[17,25] Probably, this change reflects almost three decades worth of information provided by health organisms about the chances of such containers of

Table 3 – Dengue incidence rate (per 100 thousand inhabitants) according to age group and sex, Fortaleza, Ceará, 2001, 2006, 2008, 2011 and 2012

Variables	2001	2006	2008	2011	2012
Age Group (in years)					
<9	406.9	660.3	2,331.3	1,707.4	1,114.5
10-19	631.4	856.0	1,821.3	1,793.3	1,881.1
20-49	1,047.0	856.6	1,378.6	1,350.7	1,743.0
50-79	886.5	637.5	1,045.5	860.2	1,156.4
≥80	443.1	529.4	896.4	654.8	551.4
Sex					
Male	488.2	609.4	1,313.5	1,345.7	1,431.1
Female	673.9	662.0	1,469.6	1,422.2	1,675.5

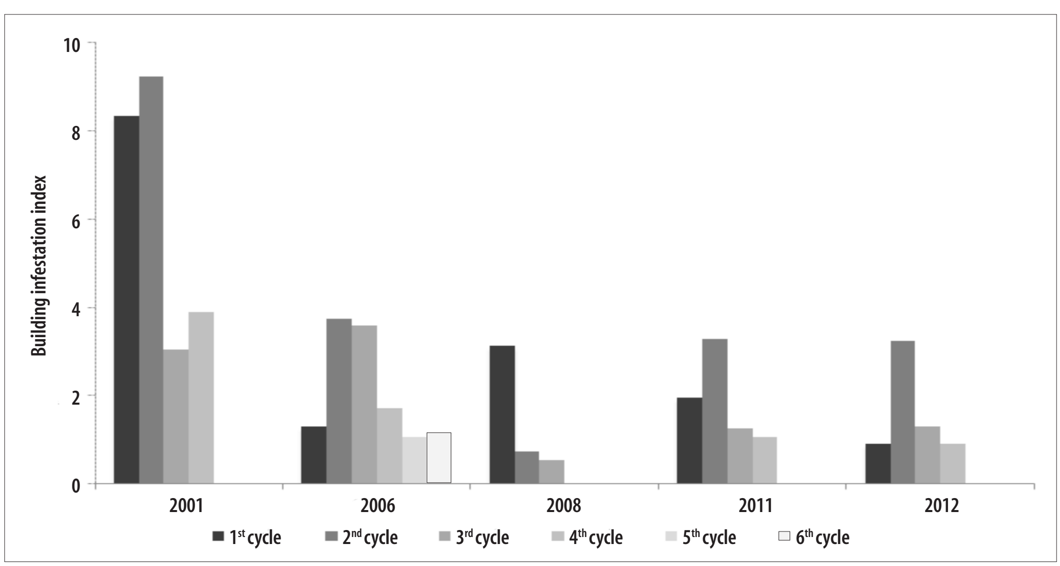

Figure 2 – *Aedes aegypti* building infestation index, according to household visit control cycle. Fortaleza, Ceará, 2001, 2006, 2008, 2011 and 2012

Table 4 – Percentage of deposits of water infested with the *Aedes aegypti* mosquito during epidemic years according to Regional District Office, Fortaleza, Ceará, 2001-2012

Types of Deposits	Regional District Office – SERs													
	I		II		III		IV		V		VI		Total	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Water tanks (A1)	11.6	18.1	3.5	12.5	5.8	18.4	7.7	23.1	12.1	37.8	4.8	11.8	3.5	37.8
Other containers for water storage (A2)	56.3	67.9	20.8	29.1	48.6	68.2	24.1	26.9	46.0	54.1	47.1	54.5	20.8	68.2
Plant pots and vases (B)	8.3	14.3	12.5	30.2	7.9	21.1	3.8	22.4	2.7	25.0	15.2	23.5	2.7	30.2
Drains and toilets (C)	–	8.9	30.0	50.0	5.3	7.0	26.9	30.8	3.2	6.9	4.8	18.2	–	50.0
Tires (D1)	–	1.4	–	1.2	–	1.4	–	7.7	–	0.9	–	0.8	–	7.7
Cans, jars, packages, bottles, and others (D2)	3.6	7.1	–	6.7	5.3	17.4	11.5	17.9	–	4.8	–	14.3	–	17.9
Natural deposits (E)	–	0.9	–	3.5	–	–	–	–	–	3.2	–	3.2	–	3.5

pooling water in the Northeast, as well as the control actions developed since then, such as permanently sealing water tanks, temporary sealing with nylon wire mesh, and even the use of biological mechanisms such as predatory fish.

It is important to highlight that even a relatively low *Ae. aegypti* infestation – according to the majority of larval index rapid conducted – did not prevent the occurrence of significant epidemics. Although low, the values for this indicator were almost never below 1%, according to information provided by the Municipal Health Department of Fortaleza. Furthermore, there is a higher incidence of the disease and a higher infestation rate, in the first semester of the year. Another point to be considered is that it is possible that there are differences in vector competence between regions, suggesting that in some areas the vectors can adapt more easily to environmental conditions, have longer life time, and therefore transmit dengue for a longer period.

In this scenario, dengue remains a major Public Health issue in Fortaleza. After circulating for 30 years, with four different serotypes, having the constant presence of its main vector spread out in different neighborhoods, and taking into account the recent co-circulation of other arboviruses such as Zika and chikungunya – which makes diagnosis and adequate early treatment harder to accomplish –, dengue epidemics potentially became worse.[26] The challenge right now is to understand the development of these epidemics alongside circulation of other exanthematous diseases such as measles in 2013 and 2015,[27] and Zika and chikungunya in 2015 and 2016.[28]

It will be increasingly harder to talk about confirmed cases of dengue using tests such as IgM or even NS1 as reference, given that the sensitivity and specificity of such techniques will be greatly affected by the simultaneous circulation of the other arboviruses.[29,30] The problem of sensitivity in laboratory techniques could be attenuated with the dissemination of molecular techniques of diagnosis and/or with the implementation of an integrated surveillance for arbovirus infections. The costs of these molecular techniques, however, could potentially hamper their dissemination and an integrated surveillance. Even specialists are yet to reach a consensus regarding this issue. The secondary data encompassing the records of dengue in Brazil will need to be reexamined in light of this simultaneous circulation. It is likely that we will have cases of dengue, Zika, and chikungunya confusing clinical diagnosis, which will be reflected in the number of notifications and which will thus ask for an investigation.

A limitation worth noting in this study was the theoretical framework based on secondary bibliographic databases used by local surveillance, as well as the incompleteness of some variables analyzed. The use of these data could lead to overestimation of the real number of cases that broke out during the epidemics. Notwithstanding, understanding these epidemics was useful in the identification of its main entomological and epidemiological aspects in Fortaleza.

Authors' Contributions

Oliveira RMAB and Cavalcanti LPG contributed to the conception and design of the study, as well as to the writing and critical review of the intellectual content of the manuscript. Araújo FMC contributed to data analysis and interpretation and to the writing of the manuscript. The final version of the manuscript was approved by all authors, who are responsible for all aspects of the study, ensuring its accuracy and integrity.

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